STEEL CONSTRUCTION

MANUAL

OF THE

AMERICAN INSTITUTE
OF
STEEL CONSTRUCTION

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STEEL CONSTRUCTION

A Manual for Architects, Engineers and Fabricators of Buildings and Other Steel Structures

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FOREWORD

The American Institute of Steel Construction is a service organization operating without possibility of dividends or profit. It is financed by assessments received from structural steel fabricators. It is engaged in research and in the assembling and distribution of data and information from which architects and engineers may prepare engineering plans conforming to the most advanced information available to the technical professions, and in conformity with the best industrial practices.

Executive and engineering offices are maintained in New York City.

Recognizing the merits of personal contact in the clearer understanding of data, the Institute has established district offices in various sections of the country. These offices are in charge of engineers with a background of valuable experience, and their services are available without cost to those interested or engaged in the construction industries.

The Institute does not prepare engineering plans. While every precaution has been taken so that all data and information are as accurate as possible, and while our engineers endeavor to supplement these data by conference and advice, the Institute cannot assume responsibility for errors or oversights in the use of such information or in the preparation of engineering plans.

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PREFACE TO FIFTH EDITION

The unique position which this Manual holds in engineering literature carries with it two obligations which are not always easily reconciled. On the one hand is the necessity for keeping the contents abreast of the latest technical developments and production practices. On the other hand, it is recognized that the user, through frequent reference, forms an attachment to a particular edition of the Manual and may naturally feel some annoyance when the copy with which he is familiar is superseded. In deference to this latter consideration, a new edition of the Manual is issued only when necessitated by major technical or commercial developments. This Fifth Edition reflects such developments.

In Part IV. it will be noted that the Specification for the Design, Fabrication and Erection of Structural Steel for Buildings (Riveted, Bolted and Arc Welded Construction), and the Code of Standard Practice for Steel Buildings and Bridges have both been substantially revised (the Specification as of February, 1946; the Code as of December, 1946) from the texts in former editions.

In Part I. the tables of available rolled shapes have of necessity been radically revised, to conform to the lists agreed upon by industry since the close of the war and contained in "Simplified Practice Recommendation R-216-46" of the United States Department of Commerce, National Bureau of Standards, issued February, 1946.

These changes have carried with them the necessity for many corrections, throughout most of the tables in the Manual, to ensure conformity with the revised Specification and the revised lists of shapes.

Preparation of the present Edition has been the work of a small Committee on Manual. Commencing as soon as the release of the Simplified Practice Recommendations and the revised Specification would permit, this Committee has endeavored to publish the up-to-date data as quickly as possible.

Since the Manual is widely used by designers and detailers of fabricated steel, it is earnestly desired that it be, so far as possible, perfected and rendered of the greatest convenience and serviceability. All criticism and suggestions for its improvement, forwarded to the Director of Engineering at Institute headquarters, will receive consideration in future revisions.

LIST OF SYMBOLS

A	Area
B	Bending factor (A/S)
b	Breadth or width
C	Constant
c	Distance from neutral axis to extreme fiber
D	Diameter
d	Depth
Δ	Deflection of a point of a structure
δ	Unit deformation or strain
E	Modulus of elasticity (f/δ)
e	Eccentricity of application of load
f	Unit stress
g	Gage for riveting
I	Moment of inertia
L	Length in feet
l	Length in inches
M	Moment of force including bending moment
P	Force or concentrated load
p	Pressure per unit of area
R	Reaction
r	Radius of gyration
S	Section modulus (I/c)
t	Thickness, or temperature
V	Total shear
v	Unit shear
W	Total load
w	Load per unit of length
X	Horizontal axis
x	Distance parallel to X axis
Y	Vertical axis
y	Distance parallel to Y axis

Deviations from the above symbols are indicated at the places of exception.

Unless otherwise indicated loads are expressed in **KIPS.** The term kip (abbreviation from kilo-pound) is extensively used in technical literature to designate one thousand pounds and is here used as being terse and convenient.

ARRANGEMENT OF CONTENTS

The matter contained in this Manual has been arranged to provide maximum convenience for the estimator, the designer, and the detailer, respectively, rather than to adhere to a strictly academic classification. However, in order to avoid repetition, the arrangement of certain matter, such as the detailing dimensions of rolled shapes, rolling mill practice as to tolerances and surface finish and a few other topics, does not strictly comply with this rule. In such cases suitable cross reference is made.

Furthermore, in order that the designer may concentrate advantageously on the application of design, matter that is to be found in engineering text books, such as the definitions of terms, the derivation of formulas, and similar topics, has been excluded.

PART I contains the data most frequently referred to by structural estimators and designers. In general this part includes products that are usually figured individually, whereas the details of products which it is the practice to estimate by percentage are given in Part II.

PART II contains the data most frequently required in making shop drawings not previously given in Part I.

PART III gives tables of allowable loads for stipulated conditions based on the unit stresses permitted by the A. I. S. C. Specification.

PART IV assembles the standard specifications and codes most commonly applicable to steel buildings.

PART V contains in tabulated form various data that may be needed for occasional reference.

PART I

Part I contains the data most frequently referred to by structural estimators and by structural designers engaged in proportioning steel members after ascertainment of the forces to be resisted. It is grouped in three portions, as follows:

ROLLED STEEL STRUCTURAL SHAPES

DIMENSIONS, WEIGHTS AND PROPERTIES OF REGULAR AND SPECIAL SERIES SHAPES

GENERAL INFORMATION ON BARS AND PLATES

ROLLING MILL PRACTICE

PERMISSIBLE TOLERANCES AND VARIATIONS FOR ROLLED STEEL STRUCTURAL SHAPES AND PLATES

MISCELLANEOUS DATA FOR DESIGNING AND ESTIMATING

WEIGHT AND AREA OF BARS AND PLATES

ECONOMY TABLES FOR SHAPES USED AS BEAMS

TABLES FOR DESIGN OF PLATE GIRDERS

DIMENSIONS, WEIGHTS AND PROPERTIES OF PLATE AND ANGLE GIRDER SECTIONS

WEIGHTS AND PROPERTIES OF COMPOUND BEAM SECTIONS

NET SECTION OF RIVETED TENSION MEMBERS

DIMENSIONS, WEIGHTS AND PROPERTIES OF COMPOUND COLUMN SECTIONS

WEIGHTS AND PROPERTIES OF TWO ANGLES

BEARING PLATE AND BASE PLATE DESIGN

CRANE RAILS AND FASTENINGS

EYE BARS AND STRUCTURAL ACCESSORIES

DIMENSIONS, WEIGHTS AND PROPERTIES
OF
ROLLED STEEL STRUCTURAL SHAPES

Structural Shapes are presented in Part I in two groupings, namely "Regular" and "Special." Under the grouping "Regular" Shapes are shown the popular sizes for which there is a constant demand, and such sizes are readily procurable in any size lots.

Under the grouping "Special" Shapes are shown sizes and sections for which there is a fluctuating demand and, therefore, are rolled at irregular intervals, and then only by special arrangement. Consequently the use of "Special" Shapes should generally be avoided, unless the quantity of any one size is sufficient to warrant a rolling.

"Regular" WF (Wide Flange) Shapes can be furnished from Bethlehem Steel Company or United States Steel Corporation Mills. Certain "Regular" WF Shapes can also be furnished by Inland Steel Company. "Regular" American Standard Beams, Channels and Angles are readily procurable from all mills rolling these products. The same is true of the Miscellaneous "Regular" Shapes rolled by the various mills.

All WF Shapes produced by United States Steel Corporation and Inland Steel Company have parallel face flanges. WF Shapes produced by Bethlehem Steel Company have parallel face flanges with the following exceptions: All sizes with nominal depths from 36 to 16 inches, inclusive; 14 WF 38 to 30; 12 WF 36 to 27; 10 WF 29 to 21; 8 WF 20 and 17. These shapes have a 5 per cent slope on the inside face of flange.

Due to this difference in rolling practice the properties of certain WF Shapes produced by the different mills are not precisely identical, but the difference is so small as to be practically negligible. In the interest of standardization the tables of properties show only the lesser values and are thus a trifle on the side of safety.

When WF Shapes are available either with sloping flanges or parallel flanges, the dimensions such as T, k, and g_1 (see page 15), are given for the sloping flange shapes and therefore may be used for all shapes. Where thickness of flange is given in the tables, it is, in the case of shapes with sloping flanges, the mean thickness. If necessary, additional dimensions may be obtained from mill catalogs.

All American Standard Beam and Channel Shapes have a slope on the inside face of flange of 16-2/3 per cent. The Miscellaneous Column and Beam Shapes in the Regular Series, as well as the Channels and the Tees in the Special Series, have various flange slopes whose amounts may be ascertained from the respective mill catalogs.

It is the practice of the rolling mills to use the terms "Sections" or "Shapes" when referring to their finished flanged product. The term "Shapes" is used throughout this Manual as being the standard practice of the Fabricating Industry.

When designating rolled steel shapes on drawings it is desirable that a standard method of abbreviating be followed that will identify the group without reference to the manufacturer, and without the use of inch and pound marks. To this end it is recommended that the nominal depth of shape, its group symbol, and its weight in pounds per linear foot, be abbreviated in the manner exemplified below. For completeness a convenient method of abbreviating the sizes of plates and bars is included.

Group	Pages of Part I of Manual	Example
Wide Flange Shapes	12-25	24 WF 76
Miscellaneous Light Beams	24-25	6 B 12
Miscellaneous Light Columns	26-27	8 x 8 M 34.3
Miscellaneous Light Beams	26-27	8 M 17
Junior Beams	26-27	7 Jr. 5.5
Junior Channels	26-27	10 Jr. ⊔ 8.4
American Standard Beams	28-29	15 I 42.9
American Standard Channels	30-31	9 ⊔ 13.4
Equal Leg Angles	32-33	L 3 x 3 x ¼
Unequal Leg Angles	34-37	L 7 x 4 x ½
Structural Tees	38-43	ST 5 WF 10.5
" "	44-45	ST 6 I 20.4
		ST 6 B 9.5
		ST 6 Jr. 5.90
Bearing Piles	46	14 BP 73
Car and Ship Channels	48-51	12 x 4 ⊔ 44.5
Tees (Flange by Stem)	52	T 3 x 3 x 6.7
Zees	53	Z 6 x 3½ x 15.7
Bulb Angles	54-55	Bulb L 6 x 3½ x 17.4
Plates	59-60	Pl. 18 x ½
Square Bars	72-73	Bar 1 ⌷
Round Bars	72-73	Bar 1¼ Φ
Flat Bars	74	Bar 2½ x ¼

The abbreviations exemplified above are intended only for use on design drawings. When lists of material are being prepared for ordering from the mills, the requirements of the respective mills from which the material in question is to be ordered should be observed.

Space does not permit of the inclusion in this Manual of data on every rolled steel product occasionally useful in building construction. For products herein omitted, reference should be made to the various mill catalogs.

REGULAR SERIES SHAPES

PAGES 12-46

The designation "Regular Series" is applied in this Manual to those Shapes for which a steady demand has led to ready availability; the use of "Regular Shapes" alone in design is therefore advisable.

Not all "Regular Series" Shapes are produced by all manufacturers; this holds particularly for the lighter shapes used largely in floors and for housing.

"Regular" WF (Wide Flange) Shapes can be furnished from Bethlehem Steel Company or United States Steel Corporation mills. "Regular" 24 x 9, 21 x $8\frac{1}{4}$, 18 x $7\frac{1}{2}$, 16 x 7, 14 x $6\frac{3}{4}$, 12 x $6\frac{1}{2}$, 10 x $5\frac{3}{4}$, and 8 x $5\frac{1}{4}$ WF Shapes can also be furnished by Inland Steel Co.

"Regular" American Standard Beams, Channels and Angles are readily procurable from most structural mills.

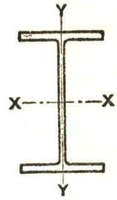
"Regular" Structural Tees are as readily procurable as the beams from which they are split.

The "Regular" Shapes listed on pages 24 and 26 are readily available, but only from certain mills as listed at the foot of the respective pages.

For notes regarding "Special Series" Shapes see page 47.

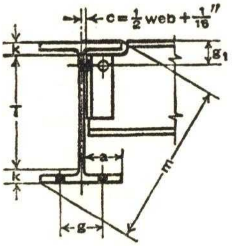
WF SHAPES

PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area	Depth	Flange Width	Flange Thickness	Web Thickness	Axis X-X I	Axis X-X S	Axis X-X r	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r
In.	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.⁴	In.³	In.
36 x 16½	300	88.17	36.72	16.655	1.680	.945	20290.2	1105.1	15.17	1225.2	147.1	3.73
	280	82.32	36.50	16.595	1.570	.885	18819.3	1031.2	15.12	1127.5	135.9	3.70
	260	76.56	36.24	16.555	1.440	.845	17233.8	951.1	15.00	1020.6	123.3	3.65
	245	72.03	36.06	16.512	1.350	.802	16092.2	892.5	14.95	944.7	114.4	3.62
	230	67.73	35.88	16.475	1.260	.765	14988.4	835.5	14.88	870.9	105.7	3.59
36 x 12	194	57.11	36.48	12.117	1.260	.770	12103.4	663.6	14.56	355.4	58.7	2.49
	182	53.54	36.32	12.072	1.180	.725	11281.5	621.2	14.52	327.7	54.3	2.47
	170	49.98	36.16	12.027	1.100	.680	10470.0	579.1	14.47	300.6	50.0	2.45
	160	47.09	36.00	12.000	1.020	.653	9738.8	541.0	14.38	275.4	45.9	2.42
	150	44.16	35.84	11.972	.940	.625	9012.1	502.9	14.29	250.4	41.8	2.38
33 x 15¾	240	70.52	33.50	15.865	1.400	.830	13585.1	811.1	13.88	874.3	110.2	3.52
	220	64.73	33.25	15.810	1.275	.775	12312.1	740.6	13.79	782.4	99.0	3.48
	200	58.79	33.00	15.750	1.150	.715	11048.2	669.6	13.71	691.7	87.8	3.43
33 x 11½	152	44.71	33.50	11.565	1.055	.635	8147.6	486.4	13.50	256.1	44.3	2.39
	141	41.51	33.31	11.535	.960	.605	7442.2	446.8	13.39	229.7	39.8	2.35
	130	38.26	33.10	11.510	.855	.580	6699.0	404.8	13.23	201.4	35.0	2.29
30 x 15	210	61.78	30.38	15.105	1.315	.775	9872.4	649.9	12.64	707.9	93.7	3.38
	190	55.90	30.12	15.040	1.185	.710	8825.9	586.1	12.57	624.6	83.1	3.34
	172	50.65	29.88	14.985	1.065	.655	7891.5	528.2	12.48	550.1	73.4	3.30
30 x 10½	132	38.83	30.30	10.551	1.000	.615	5753.1	379.7	12.17	185.0	35.1	2.18
	124	36.45	30.16	10.521	.930	.585	5347.1	354.6	12.11	169.7	32.3	2.16
	116	34.13	30.00	10.500	.850	.564	4919.1	327.9	12.00	153.2	29.2	2.12
	108	31.77	29.82	10.484	.760	.548	4461.0	299.2	11.85	135.1	25.8	2.06

See page 10 for method of designation.



WF SHAPES

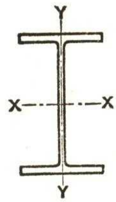
DIMENSIONS FOR DETAILING

Nominal Size	Weight per Foot	Depth	Flange Width	Flange Thickness	Web Thickness	Web Half Thickness	Distance a	Distance T	Distance k	Distance m	Distance g_1	Distance c	Usual Gage g
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
36 x 16 1/2	300	36 3/4	16 5/8	1 11/16	15/16	1/2	7 7/8	31 1/8	2 13/16	40 3/8	4	9/16	5 1/2
	280	36 1/2	16 5/8	1 9/16	7/8	7/16	7 7/8	31 1/8	2 11/16	40 1/8	4	1/2	5 1/2
	260	36 1/4	16 1/2	1 7/16	7/8	7/16	7 7/8	31 1/8	2 9/16	39 7/8	3 3/4	1/2	5 1/2
	245	36	16 1/2	1 3/8	13/16	3/8	7 7/8	31 1/8	2 7/16	39 3/4	3 3/4	7/16	5 1/2
	230	35 7/8	16 1/2	1 1/4	3/4	3/8	7 7/8	31 1/8	2 3/8	39 1/2	3 1/2	7/16	5 1/2
36 x 12	194	36 1/2	12 1/8	1 1/4	13/16	3/8	5 5/8	32 1/4	2 1/8	38 1/2	3 1/4	7/16	5 1/2
	182	36 3/8	12 1/8	1 3/16	3/4	3/8	5 5/8	32 1/4	2 1/16	38 3/8	3 1/4	7/16	5 1/2
	170	36 1/8	12	1 1/8	11/16	3/8	5 5/8	32 1/4	1 15/16	38 1/8	3 1/4	7/16	5 1/2
	160	36	12	1	11/16	5/16	5 5/8	32 1/4	1 7/8	38	3	3/8	5 1/2
	150	35 7/8	12	15/16	5/8	5/16	5 5/8	32 1/4	1 13/16	37 7/8	3	3/8	5 1/2
33 x 15 3/4	240	33 1/2	15 7/8	1 3/8	7/8	7/16	7 1/2	28 5/8	2 7/16	37 1/8	3 3/4	1/2	5 1/2
	220	33 1/4	15 3/4	1 1/4	13/16	3/8	7 1/2	28 5/8	2 5/16	36 7/8	3 1/2	7/16	5 1/2
	200	33	15 3/4	1 1/8	3/4	3/8	7 1/2	28 5/8	2 3/16	36 5/8	3 1/2	7/16	5 1/2
33 x 11 1/2	152	33 1/2	11 5/8	1 1/16	5/8	5/16	5 1/2	29 3/4	1 7/8	35 1/2	3	3/8	5 1/2
	141	33 1/4	11 1/2	15/16	5/8	5/16	5 1/2	29 3/4	1 3/4	35 1/4	3	3/8	5 1/2
	130	33 1/8	11 1/2	7/8	9/16	5/16	5 1/2	29 3/4	1 11/16	35 1/8	3	3/8	5 1/2
30 x 15	210	30 3/8	15 1/8	1 5/16	13/16	3/8	7 1/8	25 3/4	2 5/16	34	3 1/2	7/16	5 1/2
	190	30 1/8	15	1 3/16	3/4	3/8	7 1/8	25 3/4	2 3/16	33 3/4	3 1/2	7/16	5 1/2
	172	29 7/8	15	1 1/16	11/16	5/16	7 1/8	25 3/4	2 1/16	33 1/2	3 1/4	3/8	5 1/2
30 x 10 1/2	132	30 1/4	10 1/2	1	5/8	5/16	5	26 7/8	1 11/16	32 1/8	3	3/8	5 1/2
	124	30 1/8	10 1/2	15/16	5/8	5/16	5	26 7/8	1 5/8	31 7/8	3	3/8	5 1/2
	116	30	10 1/2	7/8	9/16	5/16	5	26 7/8	1 9/16	31 3/4	2 3/4	3/8	5 1/2
	108	29 7/8	10 1/2	3/4	9/16	5/16	5	26 7/8	1 1/2	31 5/8	2 3/4	3/8	5 1/2

Gage g_1 is based on k + 1 1/4", to nearest 1/4"

WF SHAPES

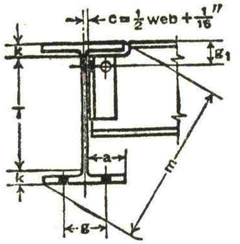
PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area	Depth	Flange Width	Flange Thickness	Web Thickness	Axis X-X I	Axis X-X S	Axis X-X r	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r
In.	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.⁴	In.³	In.
27 x 14	177	52.10	27.31	14.090	1.190	.725	6728.6	492.8	11.36	518.9	73.7	3.16
	160	47.04	27.08	14.023	1.075	.658	6018.6	444.5	11.31	458.0	65.3	3.12
	145	42.68	26.88	13.965	.975	.600	5414.3	402.9	11.26	406.9	58.3	3.09
27 x 10	114	33.53	27.28	10.070	.932	.570	4080.5	299.2	11.03	149.6	29.7	2.11
	102	30.01	27.07	10.018	.827	.518	3604.1	266.3	10.96	129.5	25.9	2.08
	94	27.65	26.91	9.990	.747	.490	3266.7	242.8	10.87	115.1	23.0	2.04
24 x 14	160	47.04	24.72	14.091	1.135	.656	5110.3	413.5	10.42	492.6	69.9	3.23
	145	42.62	24.49	14.043	1.020	.608	4561.0	372.5	10.34	434.3	61.8	3.19
	130	38.21	24.25	14.000	.900	.565	4009.5	330.7	10.24	375.2	53.6	3.13
24 x 12	120	35.29	24.31	12.088	.930	.556	3635.3	299.1	10.15	254.0	42.0	2.68
	110	32.36	24.16	12.042	.855	.510	3315.0	274.4	10.12	229.1	38.0	2.66
	100	29.43	24.00	12.000	.775	.468	2987.3	248.9	10.08	203.5	33.9	2.63
24 x 9	94	27.63	24.29	9.061	.872	.516	2683.0	220.9	9.85	102.2	22.6	1.92
	84	24.71	24.09	9.015	.772	.470	2364.3	196.3	9.78	88.3	19.6	1.89
	76	22.37	23.91	8.985	.682	.440	2096.4	175.4	9.68	76.5	17.0	1.85
21 x 13	142	41.76	21.46	13.132	1.095	.659	3403.1	317.2	9.03	385.9	58.8	3.04
	127	37.34	21.24	13.061	.985	.588	3017.2	284.1	8.99	338.6	51.8	3.01
	112	32.93	21.00	13.000	.865	.527	2620.6	249.6	8.92	289.7	44.6	2.96
21 x 9	96	28.21	21.14	9.038	.935	.575	2088.9	197.6	8.60	109.3	24.2	1.97
	82	24.10	20.86	8.962	.795	.499	1752.4	168.0	8.53	89.6	20.0	1.93
21 x 8¼	73	21.46	21.24	8.295	.740	.455	1600.3	150.7	8.64	66.2	16.0	1.76
	68	20.02	21.13	8.270	.685	.430	1478.3	139.9	8.59	60.4	14.6	1.74
	62	18.23	20.99	8.240	.615	.400	1326.8	126.4	8.53	53.1	12.9	1.71

See page 10 for method of designation.

REGULAR SERIES



WF SHAPES

DIMENSIONS FOR DETAILING

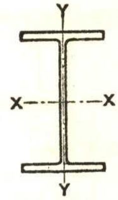
I

Nominal Size	Weight per Foot	Depth	Flange Width	Flange Thickness	Web Thickness	Web Half Thickness	Distance a	Distance T	Distance k	Distance m	Distance g_1	Distance c	Usual Gage g
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
27 x 14	177	27¼	14⅛	1 3/16	¾	⅜	6¾	23	2⅛	30¾	3¼	7/16	5½
	160	27⅛	14	1 1/16	11/16	5/16	6¾	23	2 1/16	30½	3¼	⅜	5½
	145	26⅞	14	1	⅝	5/16	6¾	23	1 15/16	30⅜	3¼	⅜	5½
27 x 10	114	27¼	10⅛	15/16	9/16	5/16	4¾	24	1⅝	29⅛	2¾	⅜	5½
	102	27⅛	10	13/16	½	¼	4¾	24	1 9/16	28⅞	2¾	5/16	5½
	94	26⅞	10	¾	½	¼	4¾	24	1 7/16	28¾	2¾	5/16	5½
24 x 14	160	24¾	14⅛	1⅛	11/16	5/16	6¾	20¾	2	28½	3¼	⅜	5½
	145	24½	14	1	⅝	5/16	6¾	20¾	1⅞	28¼	3¼	⅜	5½
	130	24¼	14	⅞	9/16	5/16	6¾	20¾	1¾	28	3	⅜	5½
24 x 12	120	24¼	12⅛	15/16	9/16	5/16	5¾	20⅞	1 11/16	27⅛	3	⅜	5½
	110	24⅛	12	⅞	½	¼	5¾	20⅞	1⅝	27	2¾	5/16	5½
	100	24	12	¾	½	¼	5¾	20⅞	1 9/16	26⅞	2¾	5/16	5½
24 x 9	94	24¼	9	⅞	½	¼	4¼	21⅜	1 7/16	25⅞	2¾	5/16	5½
	84	24⅛	9	¾	½	¼	4¼	21⅜	1⅜	25¾	2¾	5/16	5½
	76	23⅞	9	11/16	7/16	¼	4¼	21⅜	1¼	25⅝	2½	5/16	5½
21 x 13	142	21½	13⅛	1⅛	11/16	⅜	6¼	17¾	1⅞	25¼	3	7/16	5½
	127	21¼	13	1	9/16	5/16	6¼	17¾	1¾	25	3	⅜	5½
	112	21	13	⅞	9/16	¼	6¼	17¾	1⅝	24¾	3	5/16	5½
21 x 9	96	21⅛	9	15/16	9/16	5/16	4¼	18	1 9/16	23	2¾	⅜	5½
	82	20⅞	9	13/16	½	¼	4¼	18	1 7/16	22¾	2¾	5/16	5½
21 x 8¼	73	21¼	8¼	¾	½	¼	4	18⅝	1 5/16	22⅞	2½	5/16	5½
	68	21⅛	8¼	11/16	7/16	¼	4	18⅝	1¼	22¾	2½	5/16	5½
	62	21	8¼	⅝	⅜	3/16	4	18⅝	1 3/16	22⅝	2½	¼	5½

Gage g_1 is based on k + 1¼", to nearest ¼".

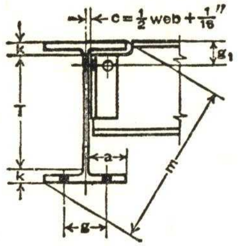
WF SHAPES

PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area	Depth	Flange Width	Flange Thick-ness	Web Thick-ness	Axis X-X I	Axis X-X S	Axis X-X r	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r
In.	Lb.	In.^{2}	In.	In.	In.	In.	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.
18 x 11¾	114	33.51	18.48	11.833	.991	.595	2033.8	220.1	7.79	255.6	43.2	2.76
	105	30.86	18.32	11.792	.911	.554	1852.5	202.2	7.75	231.0	39.2	2.73
	96	28.22	18.16	11.750	.831	.512	1674.7	184.4	7.70	206.8	35.2	2.71
18 x 8¾	85	24.97	18.32	8.838	.911	.526	1429.9	156.1	7.57	99.4	22.5	2.00
	77	22.63	18.16	8.787	.831	.475	1286.8	141.7	7.54	88.6	20.2	1.98
	70	20.56	18.00	8.750	.751	.438	1153.9	128.2	7.49	78.5	17.9	1.95
	64	18.80	17.87	8.715	.686	.403	1045.8	117.0	7.46	70.3	16.1	1.93
18 x 7½	60	17.64	18.25	7.558	.695	.416	984.0	107.8	7.47	47.1	12.5	1.63
	55	16.19	18.12	7.532	.630	.390	889.9	98.2	7.41	42.0	11.1	1.61
	50	14.71	18.00	7.500	.570	.358	800.6	89.0	7.38	37.2	9.9	1.59
16 x 11½	96	28.22	16.32	11.533	.875	.535	1355.1	166.1	6.93	207.2	35.9	2.71
	88	25.87	16.16	11.502	.795	.504	1222.6	151.3	6.87	185.2	32.2	2.67
16 x 8½	78	22.92	16.32	8.586	.875	.529	1042.6	127.8	6.74	87.5	20.4	1.95
	71	20.86	16.16	8.543	.795	.486	936.9	115.9	6.70	77.9	18.2	1.93
	64	18.80	16.00	8.500	.715	.443	833.8	104.2	6.66	68.4	16.1	1.91
	58	17.04	15.86	8.464	.645	.407	746.4	94.1	6.62	60.5	14.3	1.88
16 x 7	50	14.70	16.25	7.073	.628	.380	655.4	80.7	6.68	34.8	9.8	1.54
	45	13.24	16.12	7.039	.563	.346	583.3	72.4	6.64	30.5	8.7	1.52
	40	11.77	16.00	7.000	.503	.307	515.5	64.4	6.62	26.5	7.6	1.50
	36	10.59	15.85	6.992	.428	.299	446.3	56.3	6.49	22.1	6.3	1.45

See page 10 for method of designation.



WF SHAPES

DIMENSIONS FOR DETAILING

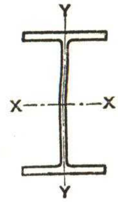
Nominal Size	Weight per Foot	Depth	Flange		Web		Distance						Usual Gage
			Width	Thickness	Thickness	Half Thickness	a	T	k	m	g_1	c	g
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
18 x 11 3/4	114	18 1/2	11 7/8	1	5/8	5/16	5 5/8	15 1/8	1 11/16	22	3	3/8	5 1/2
	105	18 3/8	11 3/4	15/16	9/16	5/16	5 5/8	15 1/8	1 5/8	21 7/8	2 3/4	3/8	5 1/2
	96	18 1/8	11 3/4	13/16	1/2	1/4	5 5/8	15 1/8	1 1/2	21 3/4	2 3/4	5/16	5 1/2
18 x 8 3/4	85	18 3/8	8 7/8	15/16	9/16	1/4	4 1/8	15 3/8	1 1/2	20 3/8	2 3/4	5/16	5 1/2
	77	18 1/8	8 3/4	13/16	1/2	1/4	4 1/8	15 3/8	1 3/8	20 1/8	2 3/4	5/16	5 1/2
	70	18	8 3/4	3/4	7/16	1/4	4 1/8	15 3/8	1 5/16	20	2 3/4	5/16	5 1/2
	64	17 7/8	8 3/4	11/16	7/16	3/16	4 1/8	15 3/8	1 1/4	20	2 1/2	1/4	5 1/2
18 x 7 1/2	60	18 1/4	7 1/2	11/16	7/16	3/16	3 5/8	15 7/8	1 3/16	19 7/8	2 1/2	1/4	3 1/2
	55	18 1/8	7 1/2	5/8	3/8	3/16	3 5/8	15 7/8	1 1/8	19 5/8	2 1/2	1/4	3 1/2
	50	18	7 1/2	9/16	3/8	3/16	3 5/8	15 7/8	1 1/16	19 1/2	2 1/4	1/4	3 1/2
16 x 11 1/2	96	16 3/8	11 1/2	7/8	9/16	5/16	5 1/2	13 1/8	1 5/8	20	2 3/4	3/8	5 1/2
	88	16 1/8	11 1/2	13/16	1/2	1/4	5 1/2	13 1/8	1 1/2	19 7/8	2 3/4	5/16	5 1/2
16 x 8 1/2	78	16 3/8	8 5/8	7/8	9/16	1/4	4	13 3/8	1 1/2	18 1/2	2 3/4	5/16	5 1/2
	71	16 1/8	8 1/2	13/16	1/2	1/4	4	13 3/8	1 3/8	18 1/4	2 3/4	5/16	5 1/2
	64	16	8 1/2	11/16	7/16	1/4	4	13 3/8	1 5/16	18 1/8	2 1/2	5/16	5 1/2
	58	15 7/8	8 1/2	5/8	7/16	1/4	4	13 3/8	1 1/4	18	2 1/2	5/16	5 1/2
16 x 7	50	16 1/4	7 1/8	5/8	3/8	3/16	3 3/8	14	1 1/8	17 3/4	2 1/2	1/4	3 1/2
	45	16 1/8	7	9/16	3/8	3/16	3 3/8	14	1 1/16	17 5/8	2 1/4	1/4	3 1/2
	40	16	7	1/2	5/16	3/16	3 3/8	14	1	17 1/2	2 1/4	1/4	3 1/2
	36	15 7/8	7	7/16	5/16	3/16	3 3/8	14	15/16	17 3/8	2 1/4	1/4	3 1/2

Gage g_1 is based on k + 1 1/4", to nearest 1/4".

I

WF SHAPES

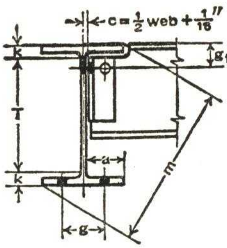
PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area	Depth	Flange Width	Flange Thickness	Web Thickness	Axis X-X I	Axis X-X S	Axis X-X r	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r
In.	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.⁴	In.³	In.
14 x 16	426	125.25	18.69	16.695	3.033	1.875	6610.3	707.4	7.26	2359.5	282.7	4.34
	398	116.98	18.31	16.590	2.843	1.770	6013.7	656.9	7.17	2169.7	261.6	4.31
	370	108.78	17.94	16.475	2.658	1.655	5454.2	608.1	7.08	1986.0	241.1	4.27
	342	100.59	17.56	16.365	2.468	1.545	4911.5	559.4	6.99	1806.9	220.8	4.24
	314	92.30	17.19	16.235	2.283	1.415	4399.4	511.9	6.90	1631.4	201.0	4.20
	287	84.37	16.81	16.130	2.093	1.310	3912.1	465.5	6.81	1466.5	181.8	4.17
	264	77.63	16.50	16.025	1.938	1.205	3526.0	427.4	6.74	1331.2	166.1	4.14
	246	72.33	16.25	15.945	1.813	1.125	3228.9	397.4	6.68	1226.6	153.9	4.12
	237	69.69	16.12	15.910	1.748	1.090	3080.9	382.2	6.65	1174.8	147.7	4.11
	228	67.06	16.00	15.865	1.688	1.045	2942.4	367.8	6.62	1124.8	141.8	4.10
	219	64.36	15.87	15.825	1.623	1.005	2798.2	352.6	6.59	1073.2	135.6	4.08
	211	62.07	15.75	15.800	1.563	.980	2671.4	339.2	6.56	1028.6	130.2	4.07
	202	59.39	15.63	15.750	1.503	.930	2538.8	324.9	6.54	979.7	124.4	4.06
	193	56.73	15.50	15.710	1.438	.890	2402.4	310.0	6.51	930.1	118.4	4.05
	184	54.07	15.38	15.660	1.378	.840	2274.8	295.8	6.49	882.7	112.7	4.04
	176	51.73	15.25	15.640	1.313	.820	2149.6	281.9	6.45	837.9	107.1	4.02
	167	49.09	15.12	15.600	1.248	.780	2020.8	267.3	6.42	790.2	101.3	4.01
	158	46.47	15.00	15.550	1.188	.730	1900.6	253.4	6.40	745.0	95.8	4.00
	150	44.08	14.88	15.515	1.128	.695	1786.9	240.2	6.37	702.5	90.6	3.99
	142	41.85	14.75	15.500	1.063	.680	1672.2	226.7	6.32	660.1	85.2	3.97
	*320	94.12	16.81	16.710	2.093	1.890	4141.7	492.8	6.63	1635.1	195.7	4.17
14 x 14½	136	39.98	14.75	14.740	1.063	.660	1593.0	216.0	6.31	567.7	77.0	3.77
	127	37.33	14.62	14.690	.998	.610	1476.7	202.0	6.29	527.6	71.8	3.76
	119	34.99	14.50	14.650	.938	.570	1373.1	189.4	6.26	491.8	67.1	3.75
	111	32.65	14.37	14.620	.873	.540	1266.5	176.3	6.23	454.9	62.2	3.73
	103	30.26	14.25	14.575	.813	.495	1165.8	163.6	6.21	419.7	57.6	3.72
	95	27.94	14.12	14.545	.748	.465	1063.5	150.6	6.17	383.7	52.8	3.71
	87	25.56	14.00	14.500	.688	.420	966.9	138.1	6.15	349.7	48.2	3.70
14 x 12	84	24.71	14.18	12.023	.778	.451	928.4	130.9	6.13	225.5	37.5	3.02
	78	22.94	14.06	12.000	.718	.428	851.2	121.1	6.09	206.9	34.5	3.00
14 x 10	74	21.76	14.19	10.072	.783	.450	796.8	112.3	6.05	133.5	26.5	2.48
	68	20.00	14.06	10.040	.718	.418	724.1	103.0	6.02	121.2	24.1	2.46
	61	17.94	13.91	10.000	.643	.378	641.5	92.2	5.98	107.3	21.5	2.45

*Column core section.
See page 10 for method of designation.

REGULAR SERIES



WF SHAPES

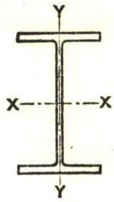
DIMENSIONS FOR DETAILING

Nominal Size	Weight per Foot	Depth	Flange Width	Flange Thickness	Web Thickness	Web Half Thickness	Distance a	Distance T	Distance k	Distance m	Distance g₁	Distance c	Usual Gage g
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
14 x 16	426	18¾	16¾	3 1/16	1⅞	15/16	7⅜	11⅜	3⅝	25⅛	5	1	3—5½—3
	398	18¼	16⅝	2 13/16	1 13/16	⅞	7⅜	11⅜	3 7/16	24¾	4¾	15/16	
	370	18	16½	2 11/16	1 11/16	13/16	7⅜	11⅜	3¼	24⅜	4½	⅞	
	342	17½	16⅜	2 7/16	1 9/16	13/16	7⅜	11⅜	3 1/16	24	4¼	⅞	
	314	17¼	16¼	2 5/16	1 7/16	¾	7⅜	11⅜	2⅞	23¾	4¼	13/16	
	287	16¾	16⅛	2 1/16	1 5/16	11/16	7⅜	11⅜	2 11/16	23⅜	4	¾	
	264	16½	16	1 15/16	1¼	⅝	7⅜	11⅜	2 9/16	23	3¾	11/16	
	246	16¼	16	1 13/16	1⅛	9/16	7⅜	11⅜	2 7/16	22⅞	3¾	⅝	
	237	16⅛	15⅞	1¾	1⅛	9/16	7⅜	11⅜	2⅜	22¾	3¾	⅝	
	228	16	15⅞	1 11/16	1 1/16	9/16	7⅜	11⅜	2 5/16	22⅝	3½	⅝	
	219	15⅞	15⅞	1⅝	1	½	7⅜	11⅜	2¼	22½	3½	9/16	
	211	15¾	15¾	1 9/16	1	½	7⅜	11⅜	2 3/16	22⅜	3½	9/16	
	202	15⅝	15¾	1½	15/16	½	7⅜	11⅜	2⅛	22¼	3½	9/16	
	193	15½	15¾	1 7/16	⅞	7/16	7⅜	11⅜	2 1/16	22⅛	3¼	½	
	184	15⅜	15⅝	1⅜	⅞	7/16	7⅜	11⅜	2	22	3¼	½	
	176	15¼	15⅝	1 5/16	13/16	7/16	7⅜	11⅜	1 15/16	21⅞	3¼	½	
	167	15⅛	15⅝	1¼	13/16	⅜	7⅜	11⅜	1⅞	21¾	3¼	7/16	
	158	15	15½	1 3/16	¾	⅜	7⅜	11⅜	1 13/16	21⅝	3	7/16	
	150	14⅞	15½	1⅛	11/16	⅜	7⅜	11⅜	1¾	21½	3	7/16	
	142	14¾	15½	1 1/16	11/16	⅜	7⅜	11⅜	1 11/16	21½	3	7/16	
	*320	16¾	16¾	2 1/16	1⅞	15/16	7⅜	11⅜	2 11/16	23¾	4	1	
14 x 14½	136	14¾	14¾	1 1/16	11/16	⅜	7	11⅜	1 11/16	20⅞	3	7/16	5½
	127	14⅝	14¾	1	⅝	5/16	7	11⅜	1⅝	20¾	3	⅜	5½
	119	14½	14⅝	15/16	9/16	5/16	7	11⅜	1 9/16	20⅝	2¾	⅜	5½
	111	14⅜	14⅝	⅞	9/16	5/16	7	11⅜	1½	20½	2¾	⅜	5½
	103	14¼	14⅝	13/16	½	¼	7	11⅜	1 7/16	20½	2¾	5/16	5½
	95	14⅛	14½	¾	½	¼	7	11⅜	1⅜	20¼	2¾	5/16	5½
	87	14	14½	11/16	7/16	¼	7	11⅜	1 5/16	20¼	2½	5/16	5½
14 x 12	84	14⅛	12	¾	7/16	¼	5¾	11⅜	1⅜	18⅝	2¾	5/16	5½
	78	14	12	11/16	7/16	¼	5¾	11⅜	1 5/16	18½	2½	5/16	5½
14 x 10	74	14¼	10⅛	13/16	7/16	¼	4¾	11⅜	1⅜	17½	2¾	5/16	5½
	68	14	10	11/16	7/16	¼	4¾	11⅜	1 5/16	17¼	2½	5/16	5½
	61	13⅞	10	⅝	⅜	3/16	4¾	11⅜	1¼	17⅛	2½	¼	5½

*Column Core Section.
Gage g_1 is based on k + 1¼″, to nearest ¼″.

WF SHAPES

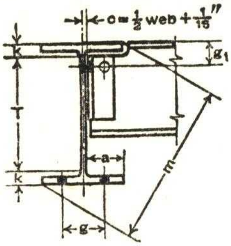
PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area	Depth	Flange Width	Flange Thickness	Web Thickness	Axis X-X I	Axis X-X S	Axis X-X r	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r
In.	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.⁴	In.³	In.
14 x 8	53	15.59	13.94	8.062	.658	.370	542.1	77.8	5.90	57.5	14.3	1.92
	48	14.11	13.81	8.031	.593	.339	484.9	70.2	5.86	51.3	12.8	1.91
	43	12.65	13.68	8.000	.528	.308	429.0	62.7	5.82	45.1	11.3	1.89
14 x 6¾	38	11.17	14.12	6.776	.513	.313	385.3	54.6	5.87	24.6	7.3	1.49
	34	10.00	14.00	6.750	.453	.287	339.2	48.5	5.83	21.3	6.3	1.46
	30	8.81	13.86	6.733	.383	.270	289.6	41.8	5.73	17.5	5.2	1.41
12 x 12	190	55.86	14.38	12.670	1.736	1.060	1892.5	263.2	5.82	589.7	93.1	3.25
	161	47.38	13.88	12.515	1.486	.905	1541.8	222.2	5.70	486.2	77.7	3.20
	133	39.11	13.38	12.365	1.236	.755	1221.2	182.5	5.59	389.9	63.1	3.16
	120	35.31	13.12	12.320	1.106	.710	1071.7	163.4	5.51	345.1	56.0	3.13
	106	31.19	12.88	12.230	.986	.620	930.7	144.5	5.46	300.9	49.2	3.11
	99	29.09	12.75	12.190	.921	.580	858.5	134.7	5.43	278.2	45.7	3.09
	92	27.06	12.62	12.155	.856	.545	788.9	125.0	5.40	256.4	42.2	3.08
	85	24.98	12.50	12.105	.796	.495	723.3	115.7	5.38	235.5	38.9	3.07
	79	23.22	12.38	12.080	.736	.470	663.0	107.1	5.34	216.4	35.8	3.05
	72	21.16	12.25	12.040	.671	.430	597.4	97.5	5.31	195.3	32.4	3.04
	65	19.11	12.12	12.000	.606	.390	533.4	88.0	5.28	174.6	29.1	3.02
12 x 10	58	17.06	12.19	10.014	.641	.359	476.1	78.1	5.28	107.4	21.4	2.51
	53	15.59	12.06	10.000	.576	.345	426.2	70.7	5.23	96.1	19.2	2.48
12 x 8	50	14.71	12.19	8.077	.641	.371	394.5	64.7	5.18	56.4	14.0	1.96
	45	13.24	12.06	8.042	.576	.336	350.8	58.2	5.15	50.0	12.4	1.94
	40	11.77	11.94	8.000	.516	.294	310.1	51.9	5.13	44.1	11.0	1.94
12 x 6½	36	10.59	12.24	6.565	.540	.305	280.8	45.9	5.15	23.7	7.2	1.50
	31	9.12	12.09	6.525	.465	.265	238.4	39.4	5.11	19.8	6.1	1.47
	27	7.97	11.95	6.500	.400	.240	204.1	34.1	5.06	16.6	5.1	1.44

See page 10 for method of designation.

REGULAR SERIES



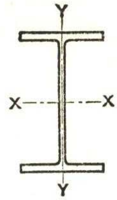
WF SHAPES
DIMENSIONS FOR DETAILING

Nominal Size	Weight per Foot	Depth	Flange Width	Flange Thickness	Web Thickness	Web Half Thickness	Distance a	Distance T	Distance k	Distance m	Distance g_1	Distance c	Usual Gage g
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
14 x 8	53	14	8	11/16	3/8	3/16	3 7/8	11 3/8	1 1/4	16 1/8	2 1/2	1/4	5 1/2
	48	13 3/4	8	9/16	3/8	3/16	3 7/8	11 3/8	1 3/16	16	2 1/2	1/4	5 1/2
	43	13 5/8	8	1/2	5/16	3/16	3 7/8	11 3/8	1 1/8	15 7/8	2 1/2	1/4	5 1/2
14 x 6 3/4	38	14 1/8	6 3/4	1/2	5/16	3/16	3 1/4	12 1/8	1	15 3/4	2 1/4	1/4	3 1/2
	34	14	6 3/4	7/16	5/16	3/16	3 1/4	12 1/8	15/16	15 5/8	2 1/4	1/4	3 1/2
	30	13 7/8	6 3/4	3/8	5/16	1/8	3 1/4	12 1/8	7/8	15 1/2	2 1/4	3/16	3 1/2
12 x 12	190	14 3/8	12 5/8	1 3/4	1 1/16	9/16	5 3/4	9 3/4	2 5/16	19 1/4	3 3/4	5/8	5 1/2
	161	13 7/8	12 1/2	1 1/2	15/16	7/16	5 3/4	9 3/4	2 1/16	18 3/4	3 1/2	1/2	5 1/2
	133	13 3/8	12 3/8	1 1/4	3/4	3/8	5 3/4	9 3/4	1 13/16	18 1/4	3 1/4	7/16	5 1/2
	120	13 1/8	12 3/8	1 1/8	3/4	3/8	5 3/4	9 3/4	1 11/16	18	3	7/16	5 1/2
	106	12 7/8	12 1/4	1	5/8	5/16	5 3/4	9 3/4	1 9/16	17 7/8	3	3/8	5 1/2
	99	12 3/4	12 1/4	15/16	5/8	5/16	5 3/4	9 3/4	1 1/2	17 3/4	2 3/4	3/8	5 1/2
	92	12 5/8	12 1/8	7/8	9/16	5/16	5 3/4	9 3/4	1 7/16	17 1/2	2 3/4	3/8	5 1/2
	85	12 1/2	12 1/8	13/16	1/2	1/4	5 3/4	9 3/4	1 3/8	17 1/2	2 3/4	5/16	5 1/2
	79	12 3/8	12 1/8	3/4	1/2	1/4	5 3/4	9 3/4	1 5/16	17 3/8	2 3/4	5/16	5 1/2
	72	12 1/4	12	11/16	7/16	1/4	5 3/4	9 3/4	1 1/4	17 1/4	2 1/2	5/16	5 1/2
	65	12 1/8	12	5/8	3/8	3/16	5 3/4	9 3/4	1 3/16	17 1/8	2 1/2	1/4	5 1/2
12 x 10	58	12 1/4	10	5/8	3/8	3/16	4 7/8	9 3/4	1 1/4	15 7/8	2 1/2	1/4	5 1/2
	53	12	10	9/16	3/8	3/16	4 7/8	9 3/4	1 3/16	15 5/8	2 1/2	1/4	5 1/2
12 x 8	50	12 1/4	8 1/8	5/8	3/8	3/16	3 7/8	9 3/4	1 1/4	14 5/8	2 1/2	1/4	5 1/2
	45	12	8	9/16	3/8	3/16	3 7/8	9 3/4	1 3/16	14 1/2	2 1/2	1/4	5 1/2
	40	12	8	1/2	5/16	3/16	3 7/8	9 3/4	1 1/8	14 3/8	2 1/2	1/4	5 1/2
12 x 6 1/2	36	12 1/4	6 5/8	9/16	5/16	3/16	3 1/8	10 3/8	15/16	14	2 1/4	1/4	3 1/2
	31	12 1/8	6 1/2	7/16	1/4	1/8	3 1/8	10 3/8	7/8	13 3/4	2 1/4	3/16	3 1/2
	27	12	6 1/2	3/8	1/4	1/8	3 1/8	10 3/8	13/16	13 5/8	2 1/4	3/16	3 1/2

Gage g_1 is based on k + 1 1/4", to nearest 1/4".

WF SHAPES

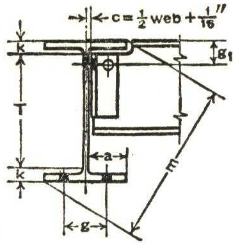
PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area	Depth	Flange		Web Thickness	Axis X-X			Axis Y-Y		
				Width	Thickness		I	S	r	I	S	r
In.	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.⁴	In.³	In.
10 x 10	112	32.92	11.38	10.415	1.248	.755	718.7	126.3	4.67	235.4	45.2	2.67
	100	29.43	11.12	10.345	1.118	.685	625.0	112.4	4.61	206.6	39.9	2.65
	89	26.19	10.88	10.275	.998	.615	542.4	99.7	4.55	180.6	35.2	2.63
	77	22.67	10.62	10.195	.868	.535	457.2	86.1	4.49	153.4	30.1	2.60
	72	21.18	10.50	10.170	.808	.510	420.7	80.1	4.46	141.8	27.9	2.59
	66	19.41	10.38	10.117	.748	.457	382.5	73.7	4.44	129.2	25.5	2.58
	60	17.66	10.25	10.075	.683	.415	343.7	67.1	4.41	116.5	23.1	2.57
	54	15.88	10.12	10.028	.618	.368	305.7	60.4	4.39	103.9	20.7	2.56
	49	14.40	10.00	10.000	.558	.340	272.9	54.6	4.35	93.0	18.6	2.54
10 x 8	45	13.24	10.12	8.022	.618	.350	248.6	49.1	4.33	53.2	13.3	2.00
	39	11.48	9.94	7.990	.528	.318	209.7	42.2	4.27	44.9	11.2	1.98
	33	9.71	9.75	7.964	.433	.292	170.9	35.0	4.20	36.5	9.2	1.94
10 x 5¾	29	8.53	10.22	5.799	.500	.289	157.3	30.8	4.29	15.2	5.2	1.34
	25	7.35	10.08	5.762	.430	.252	133.2	26.4	4.26	12.7	4.4	1.31
	21	6.19	9.90	5.750	.340	.240	106.3	21.5	4.14	9.7	3.4	1.25
8 x 8	67	19.70	9.00	8.287	.933	.575	271.8	60.4	3.71	88.6	21.4	2.12
	58	17.06	8.75	8.222	.808	.510	227.3	52.0	3.65	74.9	18.2	2.10
	48	14.11	8.50	8.117	.683	.405	183.7	43.2	3.61	60.9	15.0	2.08
	40	11.76	8.25	8.077	.558	.365	146.3	35.5	3.53	49.0	12.1	2.04
	35	10.30	8.12	8.027	.493	.315	126.5	31.1	3.50	42.5	10.6	2.03
	31	9.12	8.00	8.000	.433	.288	109.7	27.4	3.47	37.0	9.2	2.01
8 x 6½	28	8.23	8.06	6.540	.463	.285	97.8	24.3	3.45	21.6	6.6	1.62
	24	7.06	7.93	6.500	.398	.245	82.5	20.8	3.42	18.2	5.6	1.61
8 x 5¼	20	5.88	8.14	5.268	.378	.248	69.2	17.0	3.43	8.5	3.2	1.20
	17	5.00	8.00	5.250	.308	.230	56.4	14.1	3.36	6.7	2.6	1.16

See page 10 for method of designation.

REGULAR SERIES



WF SHAPES

DIMENSIONS FOR DETAILING

Nominal Size	Weight per Foot	Depth	Flange Width	Flange Thickness	Web Thickness	Web Half Thickness	Distance a	Distance T	Distance k	Distance m	Distance g_1	Distance c	Usual Gage g
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
10 x 10	112	11 3/8	10 3/8	1 1/4	3/4	3/8	4 7/8	7 7/8	1 3/4	15 1/2	3	7/16	5 1/2
	100	11 1/8	10 3/8	1 1/8	11/16	3/8	4 7/8	7 7/8	1 5/8	15 1/4	3	7/16	5 1/2
	89	10 7/8	10 1/4	1	5/8	5/16	4 7/8	7 7/8	1 1/2	15	2 3/4	3/8	5 1/2
	77	10 5/8	10 1/4	7/8	9/16	5/16	4 7/8	7 7/8	1 3/8	14 3/4	2 3/4	3/8	5 1/2
	72	10 1/2	10 1/8	13/16	1/2	1/4	4 7/8	7 7/8	1 5/16	14 5/8	2 3/4	5/16	5 1/2
	66	10 3/8	10 1/8	3/4	7/16	1/4	4 7/8	7 7/8	1 1/4	14 1/2	2 1/2	5/16	5 1/2
	60	10 1/4	10 1/8	11/16	7/16	1/4	4 7/8	7 7/8	1 3/16	14 3/8	2 1/2	5/16	5 1/2
	54	10 1/8	10	5/8	3/8	3/16	4 7/8	7 7/8	1 1/8	14 1/4	2 1/2	1/4	5 1/2
	49	10	10	9/16	3/8	3/16	4 7/8	7 7/8	1 1/16	14 1/8	2 1/2	1/4	5 1/2
10 x 8	45	10 1/8	8	5/8	3/8	3/16	3 7/8	7 7/8	1 1/8	13	2 1/2	1/4	5 1/2
	39	10	8	1/2	5/16	3/16	3 7/8	7 7/8	1 1/16	12 7/8	2 1/2	1/4	5 1/2
	33	9 3/4	8	7/16	5/16	3/16	3 7/8	7 7/8	15/16	12 5/8	2 1/4	1/4	5 1/2
10 x 5 3/4	29	10 1/4	5 3/4	1/2	5/16	3/16	2 3/4	8 1/2	7/8	11 3/4	2 1/4	1/4	2 3/4
	25	10 1/8	5 3/4	7/16	1/4	1/8	2 3/4	8 1/2	13/16	11 5/8	2 1/4	3/16	2 3/4
	21	9 7/8	5 3/4	5/16	1/4	1/8	2 3/4	8 1/2	11/16	11 1/2	2	3/16	2 3/4
8 x 8	67	9	8 1/4	15/16	9/16	5/16	3 7/8	6 3/8	1 5/16	12 1/4	2 3/4	3/8	5 1/2
	58	8 3/4	8 1/4	13/16	1/2	1/4	3 7/8	6 3/8	1 3/16	12	2 1/2	5/16	5 1/2
	48	8 1/2	8 1/8	11/16	7/16	3/16	3 7/8	6 3/8	1 1/16	11 7/8	2 1/2	1/4	5 1/2
	40	8 1/4	8 1/8	9/16	3/8	3/16	3 7/8	6 3/8	15/16	11 5/8	2 1/4	1/4	5 1/2
	35	8 1/8	8	1/2	5/16	3/16	3 7/8	6 3/8	7/8	11 1/2	2 1/4	1/4	5 1/2
	31	8	8	7/16	5/16	3/16	3 7/8	6 3/8	13/16	11 3/8	2 1/4	1/4	5 1/2
8 x 6 1/2	28	8	6 1/2	7/16	5/16	1/8	3 1/8	6 3/8	13/16	10 1/2	2 1/4	3/16	3 1/2
	24	7 7/8	6 1/2	3/8	1/4	1/8	3 1/8	6 3/8	3/4	10 1/4	2 1/4	3/16	3 1/2
8 x 5 1/4	20	8 1/8	5 1/4	3/8	1/4	1/8	2 1/2	6 3/4	11/16	9 3/4	2 1/4	3/16	2 3/4
	17	8	5 1/4	5/16	1/4	1/8	2 1/2	6 3/4	5/8	9 5/8	2 1/4	3/16	2 3/4

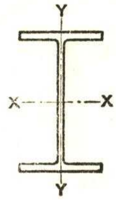
Gage g_1 is based on k + 1 1/4″, to nearest 1/4″

I

3" B @ 4.25# / ft.

I

WF SHAPES
MISCELLANEOUS (B)
COLUMNS AND BEAMS

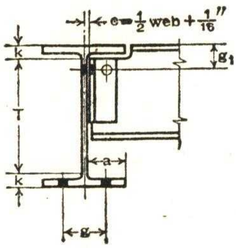


PROPERTIES FOR DESIGNING

Nominal Size	Weight per Foot	Area	Depth	Flange Width	Flange Thickness	Web Thickness	Axis X-X I	Axis X-X S	Axis X-X r	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r
In.	Lb.	In.^{2}	In.	In.	In.	In.	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.
WF SHAPES AND LIGHT COLUMNS												
*6 WF	25	7.37	6.37	6.080	.456	.320	53.5	16.8	2.69	17.1	5.6	1.52
*6 x 6	20	5.90	6.20	6.018	.367	.258	41.7	13.4	2.66	13.3	4.4	1.50
	15.5	4.62	6.00	6.000	.269	.240	30.3	10.1	2.56	9.69	3.2	1.45
*5 WF	18.5	5.45	5.12	5.025	.420	.265	25.4	9.94	2.16	8.89	3.54	1.28
*5 x 5	16	4.70	5.00	5.000	.360	.240	21.3	8.53	2.13	7.51	3.00	1.26
†4 WF	13	3.82	4.16	4.060	.345	.280	11.3	5.45	1.72	3.76	1.85	.99
LIGHT BEAMS												
‡14 x 4	17.2	5.05	14.00	4.000	.272	.210	147.3	21.0	5.40	2.65	1.32	.72
⊕12 x 4	22	6.47	12.31	4.030	.424	.260	155.7	25.3	4.91	4.55	2.26	.84
	19	5.62	12.16	4.010	.349	.240	130.1	21.4	4.81	3.67	1.83	.81
	16½	4.86	12.00	4.000	.269	.230	105.3	17.5	4.65	2.79	1.39	.76
⊕10 x 4	19	5.61	10.25	4.020	.394	.250	96.2	18.8	4.14	4.19	2.08	.86
	17	4.98	10.12	4.010	.329	.240	81.8	16.2	4.05	3.45	1.72	.83
	15	4.40	10.00	4.000	.269	.230	68.8	13.8	3.95	2.79	1.39	.80
*8 x 4	15	4.43	8.12	4.015	.314	.245	48.0	11.8	3.29	3.30	1.65	.86
	13	3.83	8.00	4.000	.254	.230	39.5	9.88	3.21	2.62	1.31	.83
*6 x 4	16	4.72	6.25	4.030	.404	.260	31.7	10.1	2.59	4.32	2.14	.96
	12	3.53	6.00	4.000	.279	.230	21.7	7.24	2.48	2.89	1.44	.90
JOISTS												
§12 x 4	14	4.14	11.91	3.970	.224	.200	88.2	14.8	4.61	2.25	1.13	.74
§10 x 4	11½	3.39	9.87	3.950	.204	.180	51.9	10.5	3.92	2.01	1.02	.77
*8 x 4	10	2.95	7.90	3.940	.204	.170	30.8	7.79	3.23	1.99	1.01	.82
*6 x 4	8½	2.50	5.83	3.940	.194	.170	14.8	5.07	2.43	1.89	.96	.87

⊕ Rolled by Bethlehem Steel Co., United States Steel Corp. and Inland Steel Co.
* Rolled by Bethlehem Steel Co. and United States Steel Corp.
§ Rolled by Bethlehem Steel Co., United States Steel Corp., Inland Steel Co. and Jones & Laughlin Steel Corp.
† Rolled by Bethlehem Steel Co.
‡ Rolled by Jones & Laughlin Steel Corp.
See page 10 for method of designation.

REGULAR SERIES



WF SHAPES
MISCELLANEOUS (B)
COLUMNS AND BEAMS

I

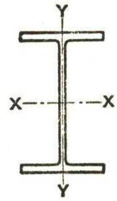
DIMENSIONS FOR DETAILING

Nominal Size	Weight per Foot	Depth	Flange		Web		Distance					Max. Flg. Rivet	Usual Gage g
			Width	Thickness	Thickness	Half Thickness	a	T	k	g_1	c		
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
WF SHAPES AND LIGHT COLUMNS													
*6 WF	25	6 3/8	6	1/2	5/16	3/16	2 7/8	4 7/8	3/4	2 1/4	1/4	7/8	3 1/2
*6 x 6	20	6 1/4	6	3/8	1/4	3/16	2 7/8	4 7/8	11/16	2	3/16	7/8	3 1/2
	15.5	6	6	1/4	1/4	1/8	2 7/8	4 7/8	9/16	2	3/16	7/8	3 1/2
*5 WF	18.5	5 1/8	5	7/16	1/4	1/8	2 3/8	3 11/16	3/4	2	3/16	7/8	2 3/4
*5 x 5	16	5	5	3/8	1/4	1/8	2 3/8	3 11/16	5/8	2	3/16	7/8	2 3/4
†4 WF	13	4 1/8	4	3/8	5/16	1/8	1 7/8	2 7/8	5/8	1 3/4	3/16	5/8	2 1/4
LIGHT BEAMS													
‡14 x 4	17.2	14	4	1/4	3/16	1/8	1 7/8	12 7/8	9/16	1 3/4	3/16	3/4	2 1/4
⊕12 x 4	22	12 1/4	4	7/16	1/4	1/8	1 7/8	10 3/4	3/4	2	3/16	3/4	2 1/4
	19	12 1/8	4	3/8	1/4	1/8	1 7/8	10 3/4	11/16	2	3/16	3/4	2 1/4
	16 1/2	12	4	1/4	1/4	1/8	1 7/8	10 3/4	5/8	1 3/4	3/16	3/4	2 1/4
⊕10 x 4	19	10 1/4	4	3/8	1/4	1/8	1 7/8	8 7/8	11/16	2	3/16	3/4	2 1/4
	17	10 1/8	4	5/16	1/4	1/8	1 7/8	8 7/8	5/8	2	3/16	3/4	2 1/4
	15	10	4	1/4	1/4	1/8	1 7/8	8 7/8	9/16	1 3/4	3/16	3/4	2 1/4
*8 x 4	15	8 1/8	4	5/16	1/4	1/8	1 7/8	6 7/8	5/8	2	3/16	3/4	2 1/4
	13	8	4	1/4	1/4	1/8	1 7/8	6 7/8	9/16	1 3/4	3/16	3/4	2 1/4
*6 x 4	16	6 1/4	4	3/8	1/4	1/8	1 7/8	4 7/8	11/16	2	3/16	3/4	2 1/4
	12	6	4	1/4	1/4	1/8	1 7/8	4 7/8	9/16	1 3/4	3/16	3/4	2 1/4
JOISTS													
§12 x 4	14	11 7/8	4	1/4	3/16	1/8	1 7/8	10 3/4	9/16	1 3/4	3/16	5/8	2 1/4
§10 x 4	11 1/2	9 7/8	4	3/16	3/16	1/8	1 7/8	8 7/8	1/2	1 3/4	3/16	5/8	2 1/4
*8 x 4	10	7 7/8	4	3/16	3/16	1/8	1 7/8	6 7/8	1/2	1 3/4	3/16	5/8	2 1/4
*6 x 4	8 1/2	5 7/8	4	3/16	3/16	1/8	1 7/8	5	7/16	1 3/4	3/16	5/8	2 1/4

⊕ Rolled by Bethlehem Steel Co., United States Steel Corp. and Inland Steel Co.
* Rolled by Bethlehem Steel Co. and United States Steel Corp.
§ Rolled by Bethlehem Steel Co., United States Steel Corp., Inland Steel Co. and Jones & Laughlin Steel Corp.
† Rolled by Bethlehem Steel Co.
‡ Rolled by Jones & Laughlin Steel Corp.

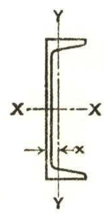
MISCELLANEOUS SHAPES (M)

PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area	Depth	Width of Flange	Web Thick-ness	AXIS X-X I	AXIS X-X S	AXIS X-X r	AXIS Y-Y I	AXIS Y-Y S	AXIS Y-Y r
In.	Lb.	In.²	In.	In.	In.	In.⁴	In.³	In.	In.⁴	In.³	In.
LIGHT COLUMNS											
* 8 x 8	34.3	10.09	8.00	8.000	.375	115.5	28.9	3.40	35.1	8.8	1.87
* 6 x 6	25.0	7.35	6.00	5.938	.313	47.0	15.7	2.53	14.9	5.0	1.43
	20.0	5.88	6.00	5.938	.250	38.8	12.9	2.57	11.4	3.8	1.39
§ 5 x 5	18.9	5.56	5.00	5.000	.313	23.8	9.5	2.08	7.8	3.1	1.20
† 4 x 4	13.0	3.82	4.00	3.937	.250	10.4	5.2	1.65	3.4	1.7	.94
STANDARD MILL BEAMS											
‡10 x 5¾	25	7.35	9.90	5.86	.35	117.0	23.6	3.99	9.84	3.36	1.16
	21	6.18	9.90	5.74	.24	107.5	21.7	4.17	9.30	3.24	1.22
‡8 x 6½	28	8.23	8.00	6.65	.39	90.1	22.5	3.31	17.73	5.33	1.47
	24	7.06	8.00	6.50	.24	83.8	21.0	3.45	16.52	5.08	1.53
‡8 x 5¼	20	5.88	8.00	5.36	.35	60.7	15.2	3.22	6.60	2.46	1.06
	17	5.00	8.00	5.25	.24	56.0	14.0	3.35	6.16	2.35	1.11
JUNIOR BEAMS											
⊕12 x 3	11.8	3.45	12.00	3.063	.175	72.2	12.0	4.57	.98	.64	.53
⊕10 x 2¾	9.0	2.64	10.00	2.688	.155	39.0	7.8	3.85	.61	.45	.48
⊕ 8 x 2¼	6.5	1.92	8.00	2.281	.135	18.7	4.7	3.12	.34	.30	.42
⊕ 7 x 2⅛	5.5	1.61	7.00	2.078	.126	12.1	3.5	2.74	.25	.24	.39
⊕ 6 x 1⅞	4.4	1.30	6.00	1.844	.114	7.3	2.4	2.37	.17	.18	.36

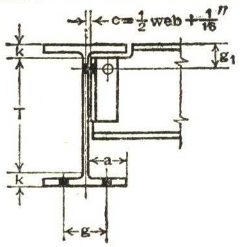
JUNIOR CHANNELS



Nominal Size	Weight per Foot	Area	Depth	Width of Flange	Web Thick-ness	AXIS X-X I	AXIS X-X S	AXIS X-X r	AXIS Y-Y I	AXIS Y-Y S	AXIS Y-Y r	AXIS Y-Y x
In.	Lb.	In.²	In.	In.	In.	In.⁴	In.³	In.	In.⁴	In.³	In.	In.
⊕12 x 1½	10.6	3.12	12.00	1.500	.190	55.8	9.3	4.23	.39	.32	.35	.27
⊕10 x 1½	8.4	2.47	10.00	1.500	.170	32.3	6.5	3.61	.33	.28	.37	.29
⊕10 x 1⅛	6.5	1.91	10.00	1.125	.150	22.1	4.4	3.47	.12	.13	.25	.19

*Rolled by United States Steel Corp. and Inland Steel Co.
§Rolled by United States Steel Corp. and Bethlehem Steel Co.-M.
†Rolled by United States Steel Corp.-M.
‡Rolled by The Phoenix Iron Co.-M.
⊕Rolled by Jones & Laughlin Steel Corp.-Jr.
See page 10 for method of designation.

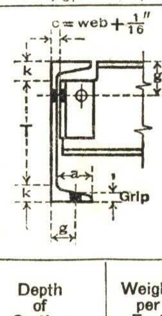
REGULAR SERIES



MISCELLANEOUS SHAPES (M)

DIMENSIONS FOR DETAILING

Nominal Size	Weight per Foot	Depth	Flange Width	Flange Mean Thickness	Web Thickness	Web Half Thickness	Distance a	Distance T	Distance k	Distance g_1	Distance c	Max. Fig. Rivet	Usual Gage g
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
LIGHT COLUMNS													
*8 x 8	34.3	8	8	7/16	3/8	3/16	3 7/8	6 1/4	7/8	2 1/2	1/4	7/8	5 1/2
*6 x 6	25.0	6	6	1/2	5/16	3/16	2 7/8	4 1/4	7/8	2 1/2	1/4	7/8	3 1/2
	20.0	6	6	3/8	1/4	1/8	2 7/8	4 3/8	13/16	2 1/4	3/16	7/8	3 1/2
§ 5 x 5	18.9	5	5	7/16	5/16	3/16	2 3/8	3 3/8	13/16	2 1/4	1/4	3/4	2 3/4
† 4 x 4	13.0	4	4	3/8	1/4	1/8	1 7/8	2 1/2	3/4	2	3/16	5/8	2 1/4
STANDARD MILL BEAMS													
‡10 x 5 3/4	25	9 15/16	5 7/8	3/8	3/8	3/16	2 3/4	8 3/8	3/4	2	1/4	3/4	2 3/4
	21	9 15/16	5 3/4	3/8	1/4	1/8	2 3/4	8 3/8	3/4	2	3/16	3/4	2 3/4
‡ 8 x 6 1/2	28	8	6 5/8	3/8	3/8	3/16	3 1/8	6 1/4	7/8	2 1/4	1/4	7/8	3 1/2
	24	8	6 1/2	3/8	1/4	1/8	3 1/8	6 1/4	7/8	2 1/4	3/16	7/8	3 1/2
‡ 8 x 5 1/4	20	8	5 3/8	5/16	3/8	3/16	2 1/2	6 5/8	11/16	2	1/4	7/8	2 3/4
	17	8	5 1/4	5/16	1/4	1/8	2 1/2	6 5/8	11/16	2	3/16	7/8	2 3/4
JUNIOR BEAMS													
⊕12 x 3	11.8	12	3	1/4	3/16	1/8	1 1/2	11	1/2	1 3/4	3/16		
⊕10 x 2 3/4	9.0	10	2 3/4	3/16	3/16	1/16	1 1/4	9 1/8	7/16	1 3/4	1/8		
⊕ 8 x 2 1/4	6.5	8	2 1/4	3/16	1/8	1/16	1 1/8	7 1/4	3/8	1 1/2	1/8		
⊕ 7 x 2 1/8	5.5	7	2 1/8	3/16	1/8	1/16	1	6 1/4	3/8	1 1/2	1/8		
⊕ 6 x 1 7/8	4.4	6	1 7/8	3/16	1/8	1/16	7/8	5 1/4	3/8	1 1/2	1/8		



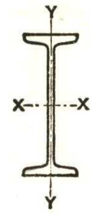
JUNIOR CHANNELS

Depth of Section	Weight per Foot	Flange Width	Flange Mean Thickness	Web Thickness	Web Half Thickness	Distance a	Distance T	Distance k	Distance g_1	Distance c
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.
⊕12 x 1 1/2	10.6	1 1/2	5/16	3/16	1/8	1 1/4	10 3/4	5/8	2	1/4
⊕10 x 1 1/2	8.4	1 1/2	1/4	3/16	1/8	1 3/8	9	1/2	1 3/4	1/4
⊕10 x 1 1/8	6.5	1 1/8	3/16	5/32	3/32	1 3/32	9 1/4	3/8	1 1/2	1/4

***Rolled by United States** Steel Corp. and Inland Steel Co.
§Rolled by United States Steel Corp. and Bethlehem Steel Co.-M.
†Rolled by United States Steel Corp.-M.
‡Rolled by The Phoenix Iron Co.-M.
⊕Rolled by Jones & Laughlin Steel Corp.-Jr.
Gage g_1 is based on k + 1 1/4", to nearest 1/4".
Gage g is permissible near ends of beam; elsewhere Specification may require reduction in rivet size.

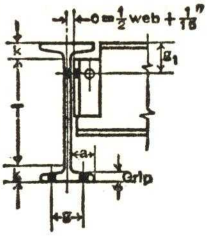
AMERICAN STANDARD BEAMS

PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area	Depth	Flange		Web Thickness	AXIS X-X			AXIS Y-Y		
				Width	Thickness		I	S	r	I	S	r
In.	Lb.	In.^{2}	In.	In.	In.	In.	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.
24 x 7⅞	120.0	35.13	24.00	8.048	1.102	.798	3010.8	250.9	9.26	84.9	21.1	1.56
	105.9	30.98	24.00	7.875	1.102	.625	2811.5	234.3	9.53	78.9	20.0	1.60
24 x 7	100.0	29.25	24.00	7.247	.871	.747	2371.8	197.6	9.05	48.4	13.4	1.29
	90.0	26.30	24.00	7.124	.871	.624	2230.1	185.8	9.21	45.5	12.8	1.32
	79.9	23.33	24.00	7.000	.871	.500	2087.2	173.9	9.46	42.9	12.2	1.36
20 x 7	95.0	27.74	20.00	7.200	.916	.800	1599.7	160.0	7.59	50.5	14.0	1.35
	85.0	24.80	20.00	7.053	.916	.653	1501.7	150.2	7.78	47.0	13.3	1.38
20 x 6¼	75.0	21.90	20.00	6.391	.789	.641	1263.5	126.3	7.60	30.1	9.4	1.17
	65.4	19.08	20.00	6.250	.789	.500	1169.5	116.9	7.83	27.9	8.9	1.21
18 x 6	70.0	20.46	18.00	6.251	.691	.711	917.5	101.9	6.70	24.5	7.8	1.09
	54.7	15.94	18.00	6.000	.691	.460	795.5	88.4	7.07	21.2	7.1	1.15
15 x 5½	50.0	14.59	15.00	5.640	.622	.550	481.1	64.2	5.74	16.0	5.7	1.05
	42.9	12.49	15.00	5.500	.622	.410	441.8	58.9	5.95	14.6	5.3	1.08
12 x 5¼	50.0	14.57	12.00	5.477	.659	.687	301.6	50.3	4.55	16.0	5.8	1.05
	40.8	11.84	12.00	5.250	.659	.460	268.9	44.8	4.77	13.8	5.3	1.08
12 x 5	35.0	10.20	12.00	5.078	.544	.428	227.0	37.8	4.72	10.0	3.9	.99
	31.8	9.26	12.00	5.000	.544	.350	215.8	36.0	4.83	9.5	3.8	1.01
10 x 4⅝	35.0	10.22	10.00	4.944	.491	.594	145.8	29.2	3.78	8.5	3.4	.91
	25.4	7.38	10.00	4.660	.491	.310	122.1	24.4	4.07	6.9	3.0	.97
8 x 4	23.0	6.71	8.00	4.171	.425	.441	64.2	16.0	3.09	4.4	2.1	.81
	18.4	5.34	8.00	4.000	.425	.270	56.9	14.2	3.26	3.8	1.9	.84
7 x 3⅝	20.0	5.83	7.00	3.860	.392	.450	41.9	12.0	2.68	3.1	1.6	.74
	15.3	4.43	7.00	3.660	.392	.250	36.2	10.4	2.86	2.7	1.5	.78
6 x 3⅜	17.25	5.02	6.00	3.565	.359	.465	26.0	8.7	2.28	2.3	1.3	.68
	12.5	3.61	6.00	3.330	.359	.230	21.8	7.3	2.46	1.8	1.1	.72
5 x 3	14.75	4.29	5.00	3.284	.326	.494	15.0	6.0	1.87	1.7	1.0	.63
	10.0	2.87	5.00	3.000	.326	.210	12.1	4.8	2.05	1.2	.82	.65
4 x 2⅝	9.5	2.76	4.00	2.796	.293	.326	6.7	3.3	1.56	.91	.65	.58
	7.7	2.21	4.00	2.660	.293	.190	6.0	3.0	1.64	.77	.58	.59
3 x 2⅜	7.5	2.17	3.00	2.509	.260	.349	2.9	1.9	1.15	.59	.47	.52
	5.7	1.64	3.00	2.330	.260	.170	2.5	1.7	1.23	.46	.40	.53

See page 10 for method of designation.



AMERICAN STANDARD BEAMS

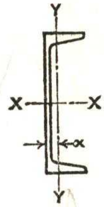
DIMENSIONS FOR DETAILING

Depth of Section	Weight per Foot	Flange Width	Flange Mean Thickness	Web Thickness	Web Half Thickness	Distance a	Distance T	Distance k	Distance g_1	Distance c	Grip	Max. Flange Rivet	Usual Gage g
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
24	120.0	8	1 1/8	13/16	7/16	3 5/8	20 1/8	1 15/16	3 1/4	1/2	1 1/8	1	4
	105.9	7 7/8	1 1/8	5/8	5/16	3 5/8	20 1/8	1 15/16	3 1/4	3/8	1 1/8	1	4
24	100.0	7 1/4	7/8	3/4	3/8	3 1/4	20 3/4	1 5/8	3	7/16	7/8	1	4
	90.0	7 1/8	7/8	5/8	5/16	3 1/4	20 3/4	1 5/8	3	3/8	7/8	1	4
	79.9	7	7/8	1/2	1/4	3 1/4	20 3/4	1 5/8	3	5/16	7/8	1	4
20	95.0	7 1/4	15/16	13/16	7/16	3 1/4	16 1/2	1 3/4	3 1/4	1/2	15/16	1	4
	85.0	7	15/16	11/16	5/16	3 1/4	16 1/2	1 3/4	3 1/4	3/8	7/8	1	4
20	75.0	6 3/8	13/16	5/8	5/16	2 7/8	16 7/8	1 9/16	3	3/8	13/16	7/8	3 1/2
	65.4	6 1/4	13/16	1/2	1/4	2 7/8	16 7/8	1 9/16	3	5/16	3/4	7/8	3 1/2
18	70.0	6 1/4	11/16	3/4	3/8	2 3/4	15 1/4	1 3/8	2 3/4	7/16	11/16	7/8	3 1/2
	54.7	6	11/16	1/2	1/4	2 3/4	15 1/4	1 3/8	2 3/4	5/16	11/16	7/8	3 1/2
15	50.0	5 5/8	5/8	9/16	5/16	2 1/2	12 1/2	1 1/4	2 3/4	3/8	9/16	3/4	3 1/2
	42.9	5 1/2	5/8	7/16	1/4	2 1/2	12 1/2	1 1/4	2 3/4	5/16	9/16	3/4	3 1/2
12	50.0	5 1/2	11/16	11/16	3/8	2 3/8	9 3/8	1 5/16	2 3/4	7/16	11/16	3/4	3
	40.8	5 1/4	11/16	1/2	1/4	2 3/8	9 3/8	1 5/16	2 3/4	5/16	5/8	3/4	3
12	35.0	5 1/8	9/16	7/16	1/4	2 3/8	9 3/4	1 1/8	2 1/2	5/16	1/2	3/4	3
	31.8	5	9/16	3/8	3/16	2 3/8	9 3/4	1 1/8	2 1/2	1/4	1/2	3/4	3
10	35.0	5	1/2	5/8	5/16	2 1/8	8	1	2 1/2	3/8	1/2	3/4	2 3/4
	25.4	4 5/8	1/2	5/16	3/16	2 1/8	8	1	2 1/2	1/4	1/2	3/4	2 3/4
8	23.0	4 1/8	7/16	7/16	1/4	1 7/8	6 1/4	7/8	2 1/4	5/16	7/16	3/4	2 1/4
	18.4	4	7/16	5/16	1/8	1 7/8	6 1/4	7/8	2 1/4	3/16	7/16	3/4	2 1/4
7	20.0	3 7/8	3/8	7/16	1/4	1 3/4	5 3/8	13/16	2	5/16	3/8	5/8	2 1/4
	15.3	3 5/8	3/8	1/4	1/8	1 3/4	5 3/8	13/16	2	3/16	3/8	5/8	2 1/4
6	17.25	3 5/8	3/8	1/2	1/4	1 1/2	4 1/2	3/4	2	5/16	3/8	5/8	2
	12.5	3 3/8	3/8	1/4	1/8	1 1/2	4 1/2	3/4	2	3/16	5/16		
5	14.75	3 1/4	5/16	1/2	1/4	1 3/8	3 5/8	11/16	2	5/16	5/16	1/2	1 3/4
	10.0	3	5/16	1/4	1/8	1 3/8	3 5/8	11/16	2	3/16	5/16	1/2	1 3/4
4	9.5	2 3/4	5/16	5/16	3/16	1 1/4	2 3/4	5/8	2	1/4	5/16	1/2	1 1/2
	7.7	2 5/8	5/16	3/16	1/8	1 1/4	2 3/4	5/8	2	3/16	5/16		
3	7.5	2 1/2	1/4	3/8	3/16	1 1/8	1 7/8	9/16		1/4	1/4	3/8	1 1/2
	5.7	2 3/8	1/4	3/16	1/8	1 1/8	1 7/8	9/16		3/16	1/4	3/8	1 1/2

Gage g_1 is based on k + 1¼", to nearest ¼".
Gage g is permissible near ends of beam; elsewhere Specification may require reduction in rivet size.

AMERICAN STANDARD CHANNELS

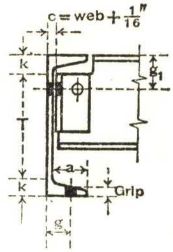
PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area	Depth	Flange Width	Flange Average Thickness	Web Thickness	Axis X-X I	Axis X-X S	Axis X-X r	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r	Axis Y-Y x
In.	Lb.	In.^{2}	In.	In.	In.	In.	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.	In.
*18 x 4	58.0	16.98	18.00	4.200	.625	.700	670.7	74.5	6.29	18.5	5.6	1.04	.88
	51.9	15.18	18.00	4.100	.625	.600	622.1	69.1	6.40	17.1	5.3	1.06	.87
	45.8	13.38	18.00	4.000	.625	.500	573.5	63.7	6.55	15.8	5.1	1.09	.89
	42.7	12.48	18.00	3.950	.625	.450	549.2	61.0	6.64	15.0	4.9	1.10	.90
15 x 3⅜	50.0	14.64	15.00	3.716	.650	.716	401.4	53.6	5.24	11.2	3.8	.87	.80
	40.0	11.70	15.00	3.520	.650	.520	346.3	46.2	5.44	9.3	3.4	.89	.78
	33.9	9.90	15.00	3.400	.650	.400	312.6	41.7	5.62	8.2	3.2	.91	.79
12 x 3	30.0	8.79	12.00	3.170	.501	.510	161.2	26.9	4.28	5.2	2.1	.77	.68
	25.0	7.32	12.00	3.047	.501	.387	143.5	23.9	4.43	4.5	1.9	.79	.68
	20.7	6.03	12.00	2.940	.501	.280	128.1	21.4	4.61	3.9	1.7	.81	.70
10 x 2⅝	30.0	8.80	10.00	3.033	.436	.673	103.0	20.6	3.42	4.0	1.7	.67	.65
	25.0	7.33	10.00	2.886	.436	.526	90.7	18.1	3.52	3.4	1.5	.68	.62
	20.0	5.86	10.00	2.739	.436	.379	78.5	15.7	3.66	2.8	1.3	.70	.61
	15.3	4.47	10.00	2.600	.436	.240	66.9	13.4	3.87	2.3	1.2	.72	.64
9 x 2½	20.0	5.86	9.00	2.648	.413	.448	60.6	13.5	3.22	2.4	1.2	.65	.59
	15.0	4.39	9.00	2.485	.413	.285	50.7	11.3	3.40	1.9	1.0	.67	.59
	13.4	3.89	9.00	2.430	.413	.230	47.3	10.5	3.49	1.8	.97	.67	.61
8 x 2¼	18.75	5.49	8.00	2.527	.390	.487	43.7	10.9	2.82	2.0	1.0	.60	.57
	13.75	4.02	8.00	2.343	.390	.303	35.8	9.0	2.99	1.5	.86	.62	.56
	11.5	3.36	8.00	2.260	.390	.220	32.3	8.1	3.10	1.3	.79	.63	.58
7 x 2⅛	14.75	4.32	7.00	2.299	.366	.419	27.1	7.7	2.51	1.4	.79	.57	.53
	12.25	3.58	7.00	2.194	.366	.314	24.1	6.9	2.59	1.2	.71	.58	.53
	9.8	2.85	7.00	2.090	.366	.210	21.1	6.0	2.72	.98	.63	.59	.55
6 x 2	13.0	3.81	6.00	2.157	.343	.437	17.3	5.8	2.13	1.1	.65	.53	.52
	10.5	3.07	6.00	2.034	.343	.314	15.1	5.0	2.22	.87	.57	.53	.50
	8.2	2.39	6.00	1.920	.343	.200	13.0	4.3	2.34	.70	.50	.54	.52
5 x 1¾	9.0	2.63	5.00	1.885	.320	.325	8.8	3.5	1.83	.64	.45	.49	.48
	6.7	1.95	5.00	1.750	.320	.190	7.4	3.0	1.95	.48	.38	.50	.49
4 x 1⅝	7.25	2.12	4.00	1.720	.296	.320	4.5	2.3	1.47	.44	.35	.46	.46
	5.4	1.56	4.00	1.580	.296	.180	3.8	1.9	1.56	.32	.29	.45	.46
3 x 1½	6.0	1.75	3.00	1.596	.273	.356	2.1	1.4	1.08	.31	.27	.42	.46
	5.0	1.46	3.00	1.498	.273	.258	1.8	1.2	1.12	.25	.24	.41	.44
	4.1	1.19	3.00	1.410	.273	.170	1.6	1.1	1.17	.20	.21	.41	.44

*Car and Shipbuilding Channel; not an American Standard.
See page 10 for method of designation.

REGULAR SERIES



AMERICAN STANDARD CHANNELS

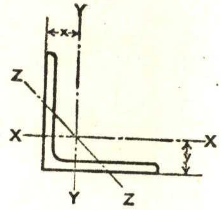
DIMENSIONS FOR DETAILING

[

Depth of Section	Weight per Foot	Flange		Web		Distance					Grip	Max. Flange Rivet	Usual Gage
		Width	Mean Thickness	Thickness	Half Thickness	a	T	k	g_1	c			g
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
*18	58.0	4¼	5/8	11/16	3/8	3½	15⅜	1 5/16	2¾	¾	5/8	1	2½
	51.9	4⅛	5/8	5/8	5/16	3½	15⅜	1 5/16	2¾	11/16	5/8	1	2½
	45.8	4	5/8	½	¼	3½	15⅜	1 5/16	2¾	9/16	5/8	1	2½
	42.7	4	5/8	7/16	¼	3½	15⅜	1 5/16	2¾	½	5/8	1	2½
15	50.0	3¾	5/8	¾	3/8	3	12⅜	1 5/16	2¾	13/16	5/8	1	2¼
	40.0	3½	5/8	9/16	¼	3	12⅜	1 5/16	2¾	5/8	5/8	1	2
	33.9	3⅜	5/8	7/16	3/16	3	12⅜	1 5/16	2¾	½	5/8	1	2
12	30.0	3⅛	½	½	¼	2⅝	9⅞	1 1/16	2½	9/16	½	7/8	1¾
	25.0	3	½	3/8	3/16	2⅝	9⅞	1 1/16	2½	7/16	½	7/8	1¾
	20.7	3	½	5/16	⅛	2⅝	9⅞	1 1/16	2½	3/8	½	7/8	1¾
10	30.0	3	7/16	11/16	3/8	2⅜	8⅛	15/16	2½	¾	7/16	¾	1¾
	25.0	2⅞	7/16	9/16	¼	2⅜	8⅛	15/16	2½	5/8	7/16	¾	1¾
	20.0	2¾	7/16	3/8	3/16	2⅜	8⅛	15/16	2½	7/16	7/16	¾	1½
	15.3	2⅝	7/16	¼	⅛	2⅜	8⅛	15/16	2½	5/16	7/16	¾	1½
9	20.0	2⅝	7/16	7/16	¼	2¼	7¼	7/8	2½	½	7/16	¾	1½
	15.0	2½	7/16	5/16	3/16	2¼	7¼	7/8	2½	3/8	7/16	¾	1⅜
	13.4	2⅜	7/16	¼	⅛	2¼	7¼	7/8	2½	5/16	3/8	¾	1⅜
8	18.75	2½	3/8	½	¼	2	6⅜	13/16	2¼	9/16	3/8	¾	1½
	13.75	2⅜	3/8	5/16	3/16	2	6⅜	13/16	2¼	3/8	3/8	¾	1⅜
	11.5	2¼	3/8	¼	⅛	2	6⅜	13/16	2¼	5/16	3/8	¾	1⅜
7	14.75	2¼	3/8	7/16	¼	1⅞	5⅜	13/16	2	½	3/8	5/8	1¼
	12.25	2¼	3/8	5/16	3/16	1⅞	5⅜	13/16	2	3/8	3/8	5/8	1¼
	9.8	2⅛	3/8	¼	⅛	1⅞	5⅜	13/16	2	5/16	3/8	5/8	1¼
6	13.0	2⅛	3/8	7/16	¼	1¾	4½	¾	2	½	5/16	5/8	1⅜
	10.5	2	3/8	5/16	3/16	1¾	4½	¾	2	3/8	3/8	5/8	1⅛
	8.2	1⅞	3/8	3/16	⅛	1¾	4½	¾	2	¼	5/16	5/8	1⅛
5	9.0	1⅞	5/16	5/16	3/16	1½	3⅝	11/16	2	3/8	5/16	½	1⅛
	6.7	1¾	5/16	3/16	⅛	1½	3⅝	11/16	2	¼	5/16	½	1⅛
4	7.25	1¾	5/16	5/16	3/16	1⅜	2¾	5/8	2	3/8	5/16	½	1
	5.4	1⅝	5/16	3/16	⅛	1⅜	2¾	5/8	2	¼	¼	½	1
3	6.0	1⅝	¼	3/8	3/16	1¼	1¾	5/8		7/16	5/16	½	7/8
	5.0	1½	¼	¼	⅛	1¼	1¾	5/8		5/16	¼	½	7/8
	4.1	1⅜	¼	3/16	⅛	1¼	1¾	5/8		¼	¼		

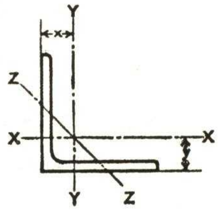
***Car and Shipbuilding** Channel; not an American Standard.
Gage g_1 is based on $k + 1\frac{1}{4}''$, to nearest $\frac{1}{4}''$.
Gage g is permissible near ends of channel; elsewhere Specification may require reduction in rivet size.

ANGLES
EQUAL LEGS
PROPERTIES FOR DESIGNING



Size	Thickness	Weight per Foot	Area	Axis X-X and Axis Y-Y: I	Axis X-X and Axis Y-Y: S	Axis X-X and Axis Y-Y: r	Axis X-X and Axis Y-Y: x or y	Axis Z-Z: r
In.	In.	Lb.	In.²	In.⁴	In.³	In.	In.	In.
8 x 8	1⅛	56.9	16.73	98.0	17.5	2.42	2.41	1.56
	1	51.0	15.00	89.0	15.8	2.44	2.37	1.56
	⅞	45.0	13.23	79.6	14.0	2.45	2.32	1.57
	¾	38.9	11.44	69.7	12.2	2.47	2.28	1.57
	⅝	32.7	9.61	59.4	10.3	2.49	2.23	1.58
	9/16	29.6	8.68	54.1	9.3	2.50	2.21	1.58
	½	26.4	7.75	48.6	8.4	2.50	2.19	1.59
6 x 6	1	37.4	11.00	35.5	8.6	1.80	1.86	1.17
	⅞	33.1	9.73	31.9	7.6	1.81	1.82	1.17
	¾	28.7	8.44	28.2	6.7	1.83	1.78	1.17
	⅝	24.2	7.11	24.2	5.7	1.84	1.73	1.18
	9/16	21.9	6.43	22.1	5.1	1.85	1.71	1.18
	½	19.6	5.75	19.9	4.6	1.86	1.68	1.18
	7/16	17.2	5.06	17.7	4.1	1.87	1.66	1.19
	⅜	14.9	4.36	15.4	3.5	1.88	1.64	1.19
	5/16	12.5	3.66	13.0	3.0	1.89	1.61	1.19
5 x 5	⅞	27.2	7.98	17.8	5.2	1.49	1.57	.97
	¾	23.6	6.94	15.7	4.5	1.51	1.52	.97
	⅝	20.0	5.86	13.6	3.9	1.52	1.48	.98
	½	16.2	4.75	11.3	3.2	1.54	1.43	.98
	7/16	14.3	4.18	10.0	2.8	1.55	1.41	.98
	⅜	12.3	3.61	8.7	2.4	1.56	1.39	.99
	5/16	10.3	3.03	7.4	2.0	1.57	1.37	.99
4 x 4	¾	18.5	5.44	7.7	2.8	1.19	1.27	.78
	⅝	15.7	4.61	6.7	2.4	1.20	1.23	.78
	½	12.8	3.75	5.6	2.0	1.22	1.18	.78
	7/16	11.3	3.31	5.0	1.8	1.23	1.16	.78
	⅜	9.8	2.86	4.4	1.5	1.23	1.14	.79
	5/16	8.2	2.40	3.7	1.3	1.24	1.12	.79
	¼	6.6	1.94	3.0	1.1	1.25	1.09	.80

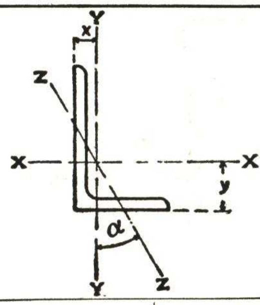
REGULAR SERIES



ANGLES
EQUAL LEGS
PROPERTIES FOR DESIGNING

Size	Thickness	Weight per Foot	Area	Axis X-X and Axis Y-Y: I	Axis X-X and Axis Y-Y: S	Axis X-X and Axis Y-Y: r	Axis X-X and Axis Y-Y: x or y	Axis Z-Z: r
In.	In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.	In.	In.
3½ x 3½	1/2	11.1	3.25	3.6	1.5	1.06	1.06	.68
	7/16	9.8	2.87	3.3	1.3	1.07	1.04	.68
	3/8	8.5	2.48	2.9	1.2	1.07	1.01	.69
	5/16	7.2	2.09	2.5	.98	1.08	.99	.69
	1/4	5.8	1.69	2.0	.79	1.09	.97	.69
3 x 3	1/2	9.4	2.75	2.2	1.1	.90	.93	.58
	7/16	8.3	2.43	2.0	.95	.91	.91	.58
	3/8	7.2	2.11	1.8	.83	.91	.89	.58
	5/16	6.1	1.78	1.5	.71	.92	.87	.59
	1/4	4.9	1.44	1.2	.58	.93	.84	.59
	3/16	3.71	1.09	.96	.44	.94	.82	.59
2½ x 2½	1/2	7.7	2.25	1.2	.72	.74	.81	.49
	3/8	5.9	1.73	.98	.57	.75	.76	.49
	5/16	5.0	1.47	.85	.48	.76	.74	.49
	1/4	4.1	1.19	.70	.39	.77	.72	.49
	3/16	3.07	.90	.55	.30	.78	.69	.49
2 x 2	3/8	4.7	1.36	.48	.35	.59	.64	.39
	5/16	3.92	1.15	.42	.30	.60	.61	.39
	1/4	3.19	.94	.35	.25	.61	.59	.39
	3/16	2.44	.71	.27	.19	.62	.57	.39
	1/8	1.65	.48	.19	.13	.63	.55	.40
1¾ x 1¾	1/4	2.77	.81	.23	.19	.53	.53	.34
	3/16	2.12	.62	.18	.14	.54	.51	.34
	1/8	1.44	.42	.13	.10	.55	.48	.35
1½ x 1½	1/4	2.34	.69	.14	.13	.45	.47	.29
	3/16	1.80	.53	.11	.10	.46	.44	.29
	1/8	1.23	.36	.08	.07	.47	.42	.30
1¼ x 1¼	1/4	1.92	.56	.08	.09	.37	.40	.24
	3/16	1.48	.43	.06	.07	.38	.38	.24
	1/8	1.01	.30	.04	.05	.38	.36	.25
1 x 1	1/4	1.49	.44	.04	.06	.29	.34	.20
	3/16	1.16	.34	.03	.04	.30	.32	.19
	1/8	.80	.23	.02	.03	.30	.30	.20

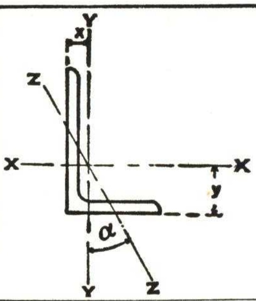
ANGLES
UNEQUAL LEGS
PROPERTIES FOR DESIGNING



Size	Thickness	Weight per Foot	Area	Axis X-X I	Axis X-X S	Axis X-X r	Axis X-X y	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r	Axis Y-Y x	Axis Z-Z r	Axis Z-Z Tan α
In.	In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.	In.	In.^{4}	In.^{3}	In.	In.	In.	
*9 x 4	1	40.8	12.00	97.0	17.6	2.84	3.50	12.0	4.0	1.00	1.00	.83	.203
	7/8	36.1	10.61	86.8	15.7	2.86	3.45	10.8	3.6	1.01	.95	.84	.208
	3/4	31.3	9.19	76.1	13.6	2.88	3.41	9.6	3.1	1.02	.91	.84	.212
	5/8	26.3	7.73	64.9	11.5	2.90	3.36	8.3	2.6	1.04	.86	.85	.216
	9/16	23.8	7.00	59.1	10.4	2.91	3.33	7.6	2.4	1.04	.83	.85	.218
	1/2	21.3	6.25	53.2	9.3	2.92	3.31	6.9	2.2	1.05	.81	.85	.220
8 x 6	1	44.2	13.00	80.8	15.1	2.49	2.65	38.8	8.9	1.73	1.65	1.28	.543
	7/8	39.1	11.48	72.3	13.4	2.51	2.61	34.9	7.9	1.74	1.61	1.28	.547
	3/4	33.8	9.94	63.4	11.7	2.53	2.56	30.7	6.9	1.76	1.56	1.29	.551
	5/8	28.5	8.36	54.1	9.9	2.54	2.52	26.3	5.9	1.77	1.52	1.29	.554
	9/16	25.7	7.56	49.3	9.0	2.55	2.50	24.0	5.3	1.78	1.50	1.30	.556
	1/2	23.0	6.75	44.3	8.0	2.56	2.47	21.7	4.8	1.79	1.47	1.30	.558
	7/16	20.2	5.93	39.2	7.1	2.57	2.45	19.3	4.2	1.80	1.45	1.31	.560
8 x 4	1	37.4	11.00	69.6	14.1	2.52	3.05	11.6	3.9	1.03	1.05	.85	.247
	7/8	33.1	9.73	62.5	12.5	2.53	3.00	10.5	3.5	1.04	1.00	.85	.253
	3/4	28.7	8.44	54.9	10.9	2.55	2.95	9.4	3.1	1.05	.95	.85	.258
	5/8	24.2	7.11	46.9	9.2	2.57	2.91	8.1	2.6	1.07	.91	.86	.262
	9/16	21.9	6.43	42.8	8.4	2.58	2.88	7.4	2.4	1.07	.88	.86	.265
	1/2	19.6	5.75	38.5	7.5	2.59	2.86	6.7	2.2	1.08	.86	.86	.267
	7/16	17.2	5.06	34.1	6.6	2.60	2.83	6.0	1.9	1.09	.83	.87	.269
7 x 4	7/8	30.2	8.86	42.9	9.7	2.20	2.55	10.2	3.5	1.07	1.05	.86	.318
	3/4	26.2	7.69	37.8	8.4	2.22	2.51	9.1	3.0	1.09	1.01	.86	.324
	5/8	22.1	6.48	32.4	7.1	2.24	2.46	7.8	2.6	1.10	.96	.86	.329
	9/16	20.0	5.87	29.6	6.5	2.24	2.44	7.2	2.4	1.11	.94	.87	.332
	1/2	17.9	5.25	26.7	5.8	2.25	2.42	6.5	2.1	1.11	.92	.87	.335
	7/16	15.8	4.62	23.7	5.1	2.26	2.39	5.8	1.9	1.12	.89	.88	.337
	3/8	13.6	3.98	20.6	4.4	2.27	2.37	5.1	1.6	1.13	.87	.88	.339

*Rolled by Bethlehem Steel Company and U. S. Steel Corp.

REGULAR SERIES



ANGLES
UNEQUAL LEGS
PROPERTIES FOR DESIGNING

Size	Thick-ness	Weight per Foot	Area	Axis X-X I	Axis X-X S	Axis X-X r	Axis X-X y	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r	Axis Y-Y x	Axis Z-Z r	Axis Z-Z Tan α
In.	In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.	In.	In.^{4}	In.^{3}	In.	In.	In.	
6 x 4	7/8	27.2	7.98	27.7	7.2	1.86	2.12	9.8	3.4	1.11	1.12	.86	.421
	3/4	23.6	6.94	24.5	6.3	1.88	2.08	8.7	3.0	1.12	1.08	.86	.428
	5/8	20.0	5.86	21.1	5.3	1.90	2.03	7.5	2.5	1.13	1.03	.86	.435
	9/16	18.1	5.31	19.3	4.8	1.90	2.01	6.9	2.3	1.14	1.01	.87	.438
	1/2	16.2	4.75	17.4	4.3	1.91	1.99	6.3	2.1	1.15	.99	.87	.440
	7/16	14.3	4.18	15.5	3.8	1.92	1.96	5.6	1.9	1.16	.96	.87	.443
	3/8	12.3	3.61	13.5	3.3	1.93	1.94	4.9	1.6	1.17	.94	.88	.446
	5/16	10.3	3.03	11.4	2.8	1.94	1.92	4.2	1.4	1.17	.92	.88	.449
6 x 3½	1/2	15.3	4.50	16.6	4.2	1.92	2.08	4.3	1.6	.97	.83	.76	.344
	3/8	11.7	3.42	12.9	3.2	1.94	2.04	3.3	1.2	.99	.79	.77	.350
	5/16	9.8	2.87	10.9	2.7	1.95	2.01	2.9	1.0	1.00	.76	.77	.352
	1/4	7.9	2.31	8.9	2.2	1.96	1.99	2.3	0.85	1.01	.74	.78	.355
5 x 3½	3/4	19.8	5.81	13.9	4.3	1.55	1.75	5.6	2.2	.98	1.00	.75	.464
	5/8	16.8	4.92	12.0	3.7	1.56	1.70	4.8	1.9	.99	.95	.75	.472
	1/2	13.6	4.00	10.0	3.0	1.58	1.66	4.1	1.6	1.01	.91	.75	.479
	7/16	12.0	3.53	8.9	2.6	1.59	1.63	3.6	1.4	1.01	.88	.76	.482
	3/8	10.4	3.05	7.8	2.3	1.60	1.61	3.2	1.2	1.02	.86	.76	.486
	5/16	8.7	2.56	6.6	1.9	1.61	1.59	2.7	1.0	1.03	.84	.76	.489
	1/4	7.0	2.06	5.4	1.6	1.61	1.56	2.2	.83	1.04	.81	.76	.492
5 x 3	1/2	12.8	3.75	9.5	2.9	1.59	1.75	2.6	1.1	.83	.75	.65	.357
	7/16	11.3	3.31	8.4	2.6	1.60	1.73	2.3	1.0	.84	.73	.65	.361
	3/8	9.8	2.86	7.4	2.2	1.61	1.70	2.0	.89	.84	.70	.65	.364
	5/16	8.2	2.40	6.3	1.9	1.61	1.68	1.8	.75	.85	.68	.66	.368
	1/4	6.6	1.94	5.1	1.5	1.62	1.66	1.4	.61	.86	.66	.66	.371

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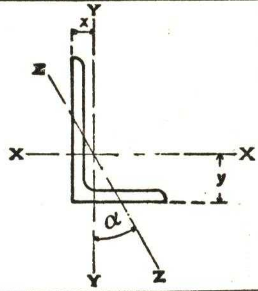
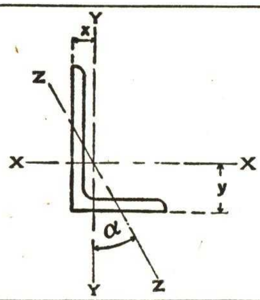
ANGLES
UNEQUAL LEGS
PROPERTIES FOR DESIGNING



Size	Thickness	Weight per Foot	Area	AXIS X-X I	AXIS X-X S	AXIS X-X r	AXIS X-X y	AXIS Y-Y I	AXIS Y-Y S	AXIS Y-Y r	AXIS Y-Y x	AXIS Z-Z r	AXIS Z-Z Tan α
In.	In.	Lb.	In.²	In.⁴	In.³	In.	In.	In.⁴	In.³	In.	In.	In.	
4 x 3½	⅝	14.7	4.30	6.4	2.4	1.22	1.29	4.5	1.8	1.03	1.04	.72	.745
	½	11.9	3.50	5.3	1.9	1.23	1.25	3.8	1.5	1.04	1.00	.72	.750
	7/16	10.6	3.09	4.8	1.7	1.24	1.23	3.4	1.4	1.05	.98	.72	.753
	⅜	9.1	2.67	4.2	1.5	1.25	1.21	3.0	1.2	1.06	.96	.73	.755
	5/16	7.7	2.25	3.6	1.3	1.26	1.18	2.6	1.0	1.07	.93	.73	.757
	¼	6.2	1.81	2.9	1.0	1.27	1.16	2.1	.81	1.07	.91	.73	.759
4 x 3	⅝	13.6	3.98	6.0	2.3	1.23	1.37	2.9	1.4	.85	.87	.64	.534
	½	11.1	3.25	5.1	1.9	1.25	1.33	2.4	1.1	.86	.83	.64	.543
	7/16	9.8	2.87	4.5	1.7	1.25	1.30	2.2	1.0	.87	.80	.64	.547
	⅜	8.5	2.48	4.0	1.5	1.26	1.28	1.9	.87	.88	.78	.64	.551
	5/16	7.2	2.09	3.4	1.2	1.27	1.26	1.7	.73	.89	.76	.65	.554
	¼	5.8	1.69	2.8	1.0	1.28	1.24	1.4	.60	.90	.74	.65	.558
3½ x 3	½	10.2	3.00	3.5	1.5	1.07	1.13	2.3	1.1	.88	.88	.62	.714
	7/16	9.1	2.65	3.1	1.3	1.08	1.10	2.1	.98	.89	.85	.62	.718
	⅜	7.9	2.30	2.7	1.1	1.09	1.08	1.9	.85	.90	.83	.62	.721
	5/16	6.6	1.93	2.3	.95	1.10	1.06	1.6	.72	.90	.81	.63	.724
	¼	5.4	1.56	1.9	.78	1.11	1.04	1.3	.59	.91	.79	.63	.727
3½x2½	½	9.4	2.75	3.2	1.4	1.09	1.20	1.4	.76	.70	.70	.53	.486
	7/16	8.3	2.43	2.9	1.3	1.09	1.18	1.2	.68	.71	.68	.54	.491
	⅜	7.2	2.11	2.6	1.1	1.10	1.16	1.1	.59	.72	.66	.54	.496
	5/16	6.1	1.78	2.2	.93	1.11	1.14	.94	.50	.73	.64	.54	.501
	¼	4.9	1.44	1.8	.75	1.12	1.11	.78	.41	.74	.61	.54	.506



ANGLES
UNEQUAL LEGS

PROPERTIES FOR DESIGNING

Size	Thickness	Weight per Foot	Area	AXIS X-X				AXIS Y-Y				AXIS Z-Z	
				I	S	r	y	I	S	r	x	r	Tan α
In.	In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.	In.	In.^{4}	In.^{3}	In.	In.	In.	
3 x 2½	½	8.5	2.50	2.1	1.0	.91	1.00	1.3	.74	.72	.75	.52	.667
	7/16	7.6	2.21	1.9	.93	.92	.98	1.2	.66	.73	.73	.52	.672
	⅜	6.6	1.92	1.7	.81	.93	.96	1.0	.58	.74	.71	.52	.676
	5/16	5.6	1.62	1.4	.69	.94	.93	.90	.49	.74	.68	.53	.680
	¼	4.5	1.31	1.2	.56	.95	.91	.74	.40	.75	.66	.53	.684
3 x 2	½	7.7	2.25	1.9	1.0	.92	1.08	.67	.47	.55	.58	.43	.414
	7/16	6.8	2.00	1.7	.89	.93	1.06	.61	.42	.55	.56	.43	.421
	⅜	5.9	1.73	1.5	.78	.94	1.04	.54	.37	.56	.54	.43	.428
	5/16	5.0	1.47	1.3	.66	.95	1.02	.47	.32	.57	.52	.43	.435
	¼	4.1	1.19	1.1	.54	.95	.99	.39	.26	.57	.49	.43	.440
	3/16	3.07	.90	.84	.41	.97	.97	.31	.20	.58	.47	.44	.446
2½ x 2	⅜	5.3	1.55	.91	.55	.77	.83	.51	.36	.58	.58	.42	.614
	5/16	4.5	1.31	.79	.47	.78	.81	.45	.31	.58	.56	.42	.620
	¼	3.62	1.06	.65	.38	.78	.79	.37	.25	.59	.54	.42	.626
	3/16	2.75	.81	.51	.29	.79	.76	.29	.20	.60	.51	.43	.631
2½x1½	⅜	4.7	1.36	.82	.52	.78	.92	.22	.20	.40	.42	.32	.340
	5/16	3.92	1.15	.71	.44	.79	.90	.19	.17	.41	.40	.32	.349
	¼	3.19	.94	.59	.36	.79	.88	.16	.14	.41	.38	.32	.357
	3/16	2.44	.72	.46	.28	.80	.85	.13	.11	.42	.35	.33	.364
2 x 1½	¼	2.77	.81	.32	.24	.62	.66	.15	.14	.43	.41	.32	.543
	3/16	2.12	.62	.25	.18	.63	.64	.12	.11	.44	.39	.32	.551
	⅛	1.44	.42	.17	.13	.64	.62	.09	.08	.45	.37	.33	.558
1¾x1¼	¼	2.34	.69	.20	.18	.54	.60	.09	.10	.35	.35	.27	.486
	3/16	1.80	.53	.16	.14	.55	.58	.07	.08	.36	.33	.27	.496
	⅛	1.23	.36	.11	.09	.56	.56	.05	.05	.37	.31	.27	.506

STRUCTURAL TEES

Structural Tees are obtained by splitting the webs of various beams, generally with the aid of rotary shears, and then restraightening to established tolerances.

The following tolerances, over or under, apply to the depth of the Tee (which is approximately ½ of the beam depth).

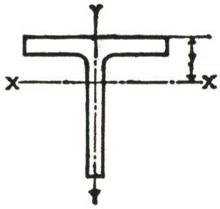
For Tees	3″ to 7½″	(inclusive)	in Depth	3/16″
" "	7¾″ to 10″	"	" "	¼″
" "	10¼″ to 12¼″	"	" "	5/16″
" "	over 12¼″	"	" "	⅜″

The above tolerances for depth of Tees include the allowable tolerances in depth for the beams before splitting. Tolerances for dimensions as set up for the beams from which the Tees are cut, will apply.

$$\text{Straightness} = \tfrac{1}{8}'' \times \frac{\text{length in feet}}{5 \text{ feet}}$$

For the sake of economy, these Split Beam Tees should be ordered in pairs.

Detail dimensions will be the same as those of the beams from which the Tees are split. Hence the beam property tables, and detailing dimension tables may be used so far as they may be applicable to Tees.

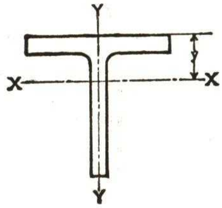


STRUCTURAL TEES
CUT FROM WF BEAMS
DIMENSIONS AND PROPERTIES FOR DESIGNING

Section Number	Weight per Foot	Area	Depth of Tee	Flange Width	Flange Average Thickness	Stem Thickness	Axis X-X I	Axis X-X S	Axis X-X r	Axis X-X y	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r
	Lb.	In.^{2}	In.	In.	In.	In.	In.^{4}	In.^{3}	In.	In.	In.^{4}	In.^{3}	In.
ST 18 WF	150	44.09	18.36	16.655	1.680	.945	1222.7	85.9	5.27	4.13	612.6	73.6	3.73
	140	41.16	18.25	16.595	1.570	.885	1133.3	79.9	5.25	4.07	563.7	67.9	3.70
	130	38.28	18.12	16.555	1.440	.845	1059.2	75.4	5.26	4.07	510.3	61.6	3.65
	122.5	36.01	18.03	16.512	1.350	.802	994.3	71.1	5.25	4.04	472.3	57.2	3.62
	115	33.86	17.94	16.475	1.260	.765	935.8	67.2	5.26	4.02	435.5	52.9	3.59
ST 18 WF	97	28.56	18.24	12.117	1.260	.770	904.0	67.3	5.63	4.81	177.7	29.3	2.49
	91	26.77	18.16	12.072	1.180	.725	844.0	63.0	5.61	4.77	163.9	27.1	2.47
	85	24.99	18.08	12.027	1.100	.680	784.7	58.8	5.60	4.74	150.3	25.0	2.45
	80	23.54	18.00	12.000	1.020	.653	741.0	56.0	5.61	4.76	137.7	22.9	2.42
	75	22.08	17.92	11.972	.940	.625	696.7	53.0	5.62	4.79	125.2	20.9	2.38
ST 16 WF	120	35.26	16.75	15.865	1.400	.830	822.5	63.2	4.83	3.73	437.2	55.1	3.52
	110	32.36	16.63	15.810	1.275	.775	754.1	58.4	4.83	3.71	391.2	49.5	3.48
	100	29.40	16.50	15.750	1.150	.715	683.6	53.3	4.82	3.67	345.8	43.9	3.43
ST 16 WF	76	22.35	16.75	11.565	1.055	.635	591.9	47.4	5.15	4.26	128.1	22.1	2.39
	70.5	20.76	16.66	11.535	.960	.603	551.8	44.7	5.16	4.30	114.9	19.9	2.35
	65	19.13	16.55	11.510	.855	.580	513.0	42.1	5.18	4.37	100.7	17.5	2.29
ST 15 WF	105	30.89	15.19	15.105	1.315	.775	578.0	48.7	4.33	3.31	354.0	46.9	3.38
	95	27.95	15.06	15.040	1.185	.710	520.4	44.1	4.31	3.26	312.3	41.5	3.34
	86	25.32	14.94	14.985	1.065	.655	471.0	40.2	4.31	3.23	275.1	36.7	3.30
ST 15 WF	66	19.41	15.15	10.551	1.000	.615	420.7	37.4	4.66	3.90	92.5	17.5	2.18
	62	18.22	15.08	10.521	.930	.585	394.8	35.3	4.65	3.90	84.8	16.1	2.16
	58.0	17.07	15.00	10.500	.850	.564	371.8	33.6	4.67	3.94	76.6	14.6	2.12
	54.0	15.88	14.91	10.484	.760	.548	349.5	32.1	4.69	4.03	67.6	12.9	2.06
ST 13 WF	88.5	26.05	13.66	14.090	1.190	.725	391.8	36.7	3.88	2.97	259.4	36.8	3.16
	80	23.72	13.54	14.023	1.075	.658	351.4	33.1	3.87	2.91	229.0	32.7	3.12
	72.5	21.34	13.44	13.965	.975	.600	316.3	29.9	3.85	2.85	203.5	29.1	3.09
ST 13 WF	57	16.77	13.64	10.070	.932	.570	288.9	28.3	4.15	3.42	74.8	14.9	2.11
	51	15.01	13.53	10.018	.827	.518	257.7	25.4	4.14	3.39	64.8	12.9	2.08
	47	13.83	13.45	9.990	.747	.490	238.5	23.7	4.15	3.41	57.5	11.5	2.04

See page 10 for method of designation.

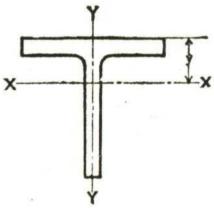
STRUCTURAL TEES
CUT FROM WF BEAMS
DIMENSIONS AND PROPERTIES FOR DESIGNING



Section Number	Weight per Foot	Area	Depth of Tee	Flange Width	Flange Average Thickness	Stem Thickness	Axis X-X I	Axis X-X S	Axis X-X r	Axis X-X y	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r
	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.	In.⁴	In.³	In.
ST 12 WF	80	23.54	12.36	14.091	1.135	.656	271.6	27.6	3.40	2.51	246.3	35.0	3.23
	72.5	21.31	12.24	14.043	1.020	.608	246.2	25.2	3.40	2.48	217.1	30.9	3.19
	65	19.11	12.13	14.000	.900	.565	222.6	23.1	3.41	2.47	187.6	26.8	3.13
ST 12 WF	60	17.64	12.16	12.088	.930	.556	213.6	22.4	3.48	2.62	127.0	21.0	2.68
	55	16.18	12.08	12.042	.855	.510	195.2	20.5	3.47	2.57	114.5	19.0	2.66
	50	14.71	12.00	12.000	.775	.468	176.7	18.7	3.46	2.54	101.8	17.0	2.63
ST 12 WF	47	13.81	12.15	9.061	.872	.516	185.9	20.3	3.67	2.99	51.1	11.3	1.92
	42	12.35	12.04	9.015	.772	.470	165.9	18.3	3.66	2.97	44.2	9.8	1.89
	38	11.18	11.95	8.985	.682	.440	151.1	16.9	3.68	3.00	38.3	8.5	1.85
ST 10 WF	71	20.88	10.73	13.132	1.095	.659	177.3	20.8	2.91	2.18	193.0	29.4	3.04
	63.5	18.67	10.62	13.061	.985	.588	155.8	18.3	2.89	2.11	169.3	25.9	3.01
	56	16.47	10.50	13.000	.865	.527	136.4	16.2	2.88	2.06	144.8	22.3	2.96
ST 10 WF	48	14.11	10.57	9.038	.935	.575	137.1	17.1	3.11	2.55	54.7	12.1	1.97
	41	12.05	10.43	8.962	.795	.499	115.4	14.5	3.09	2.48	44.8	10.0	1.93
ST 10 WF	36.5	10.73	10.62	8.295	.740	.455	110.2	13.7	3.21	2.60	33.1	7.98	1.76
	34	10.01	10.57	8.270	.685	.430	102.8	12.9	3.20	2.59	30.2	7.30	1.74
	31	9.12	10.49	8.240	.615	.400	93.7	11.9	3.21	2.59	26.6	6.45	1.71
ST 9 WF	57	16.77	9.24	11.833	.991	.595	102.6	13.9	2.47	1.85	127.8	21.6	2.76
	52.5	15.43	9.16	11.792	.911	.554	93.9	12.8	2.47	1.82	115.5	19.6	2.73
	48	14.11	9.08	11.750	.831	.512	85.3	11.7	2.46	1.78	103.4	17.6	2.71
ST 9 WF	42.5	12.49	9.16	8.838	.911	.526	84.4	11.9	2.60	2.05	49.7	11.3	2.00
	38.5	11.32	9.08	8.787	.831	.475	75.3	10.6	2.58	1.99	44.3	10.1	1.98
	35	10.28	9.00	8.750	.751	.438	68.1	9.67	2.57	1.96	39.2	8.97	1.95
	32	9.40	8.94	8.715	.686	.403	61.8	8.82	2.56	1.93	35.2	8.07	1.93
ST 9 WF	30	8.82	9.12	7.558	.695	.416	64.8	9.32	2.71	2.17	23.5	6.23	1.63
	27.5	8.09	9.06	7.532	.630	.390	59.6	8.63	2.71	2.16	21.0	5.57	1.61
	25	7.35	9.00	7.500	.570	.358	53.9	7.85	2.71	2.14	18.6	4.96	1.59
ST 8 WF	48	14.11	8.16	11.533	.875	.535	64.7	9.82	2.14	1.57	103.6	18.0	2.71
	44	12.94	8.08	11.502	.795	.504	59.5	9.11	2.14	1.55	92.6	16.1	2.67

See page 10 for method of designation.

REGULAR SERIES



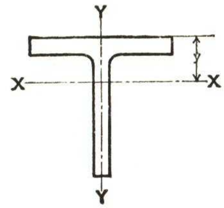
STRUCTURAL TEES
CUT FROM WF BEAMS
DIMENSIONS AND PROPERTIES FOR DESIGNING

Section Number	Weight per Foot	Area	Depth of Tee	Flange		Stem Thickness	Axis X-X				Axis Y-Y		
				Width	Average Thickness		I	S	r	y	I	S	r
	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.	In.⁴	In.³	In.
ST 8 WF	39	11.46	8.16	8.586	.875	.529	60.0	9.45	2.28	1.81	43.8	10.2	1.95
	35.5	10.43	8.08	8.543	.795	.486	54.0	8.57	2.28	1.77	38.9	9.11	1.93
	32	9.40	8.00	8.500	.715	.443	48.3	7.71	2.27	1.73	34.2	8.05	1.91
	29	8.52	7.93	8.464	.645	.407	43.6	7.00	2.26	1.70	30.2	7.14	1.88
ST 8 WF	25	7.35	8.13	7.073	.628	.380	42.2	6.77	2.40	1.89	17.4	4.92	1.54
	22.5	6.62	8.06	7.039	.563	.346	37.8	6.10	2.39	1.87	15.2	4.33	1.52
	20	5.88	8.00	7.000	.503	.307	33.2	5.37	2.37	1.82	13.3	3.79	1.50
	18	5.30	7.93	6.992	.428	.299	30.7	5.10	2.41	1.90	11.1	3.17	1.45
ST 7 WF	105.5	31.04	7.88	15.800	1.563	.980	102.2	16.2	1.81	1.57	514.3	65.1	4.07
	101	29.70	7.82	15.750	1.503	.930	95.7	15.2	1.80	1.53	489.8	62.2	4.06
	96.5	28.36	7.75	15.710	1.438	.890	90.1	14.4	1.78	1.49	465.1	59.2	4.05
	92	27.04	7.69	15.660	1.378	.840	83.9	13.4	1.76	1.45	441.4	56.4	4.04
	88	25.87	7.63	15.640	1.313	.820	80.2	12.9	1.76	1.42	418.9	53.6	4.02
	83.5	24.55	7.56	15.600	1.248	.780	75.0	12.1	1.75	1.39	395.1	50.7	4.01
	79	23.24	7.50	15.550	1.188	.730	69.3	11.3	1.73	1.34	372.5	47.9	4.00
	75	22.04	7.44	15.515	1.128	.695	64.9	10.6	1.72	1.31	351.3	45.3	3.99
	71	20.92	7.38	15.500	1.063	.680	62.1	10.2	1.72	1.29	330.1	42.6	3.97
ST 7 WF	68	19.99	7.38	14.740	1.063	.660	60.0	9.89	1.73	1.31	283.9	38.5	3.77
	63.5	18.67	7.31	14.690	.998	.610	54.7	9.04	1.71	1.26	263.8	35.9	3.76
	59.5	17.49	7.25	14.650	.938	.570	50.4	8.36	1.70	1.22	245.9	33.6	3.75
	55.5	16.33	7.19	14.620	.873	.540	46.7	7.80	1.69	1.19	227.4	31.1	3.73
	51.5	15.13	7.13	14.575	.813	.495	42.4	7.10	1.67	1.15	209.9	28.8	3.72
	47.5	13.97	7.06	14.545	.748	.465	39.1	6.58	1.67	1.12	191.9	26.4	3.71
	43.5	12.78	7.00	14.5	.688	.420	34.9	5.88	1.65	1.08	174.8	24.1	3.70
ST 7 WF	42	12.36	7.09	12.023	.778	.451	37.4	6.36	1.74	1.21	112.7	18.8	3.02
	39	11.47	7.03	12.000	.718	.428	34.8	5.96	1.74	1.19	103.5	17.2	3.00
ST 7 WF	37	10.88	7.10	10.072	.783	.450	36.1	6.26	1.82	1.32	66.7	13.3	2.48
	34	10.00	7.03	10.040	.718	.418	33.0	5.74	1.81	1.29	60.6	12.1	2.46
	30.5	8.97	6.96	10.000	.643	.378	29.2	5.13	1.80	1.25	53.6	10.7	2.45
ST 7 WF	26.5	7.79	6.97	8.062	.658	.370	27.7	4.95	1.88	1.38	28.8	7.14	1.92
	24	7.06	6.91	8.031	.593	.339	24.9	4.49	1.88	1.35	25.6	6.38	1.91
	21.5	6.32	6.84	8.000	.528	.308	22.2	4.02	1.87	1.33	22.6	5.64	1.89

See page 10 for method of designation.

STRUCTURAL TEES

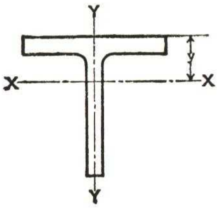
CUT FROM WF BEAMS
DIMENSIONS AND PROPERTIES FOR DESIGNING



Section Number	Weight per Foot	Area	Depth of Tee	Flange Width	Flange Average Thickness	Stem Thickness	Axis X-X I	Axis X-X S	Axis X-X r	Axis X-X y	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r
	Lb.	In.^{2}	In.	In.	In.	In.	In.^{4}	In.^{3}	In.	In.	In.^{4}	In.^{3}	In.
ST 7 WF	19	5.59	7.06	6.776	.513	.313	23.5	4.27	2.05	1.56	12.3	3.64	1.49
	17	5.00	7.00	6.750	.453	.287	21.1	3.86	2.05	1.55	10.6	3.15	1.46
	15	4.41	6.93	6.733	.383	.270	19.0	3.55	2.08	1.59	8.77	2.61	1.41
ST 6 WF	80.5	23.69	6.94	12.515	1.486	.905	62.6	11.5	1.63	1.47	243.1	38.9	3.20
	66.5	19.56	6.69	12.365	1.236	.755	48.4	9.03	1.57	1.33	195.0	31.5	3.16
	60	17.65	6.56	12.320	1.106	.710	43.4	8.22	1.57	1.28	172.5	28.0	3.13
	53	15.59	6.44	12.230	.986	.620	36.7	7.01	1.53	1.20	150.4	24.6	3.11
	49.5	14.54	6.38	12.190	.921	.580	33.7	6.46	1.52	1.16	139.1	22.8	3.09
	46	13.53	6.31	12.155	.856	.545	31.0	5.98	1.51	1.13	128.2	21.1	3.08
	42.5	12.49	6.25	12.105	.796	.495	27.8	5.38	1.49	1.08	117.7	19.5	3.07
	39.5	11.61	6.19	12.080	.736	.470	25.8	5.02	1.48	1.06	108.2	17.9	3.05
	36	10.58	6.13	12.040	.671	.430	23.1	4.53	1.48	1.02	97.6	16.2	3.04
	32.5	9.55	6.06	12.000	.606	.390	20.6	4.06	1.47	.98	87.3	14.6	3.02
ST 6 WF	29	8.53	6.10	10.014	.641	.359	19.0	3.75	1.49	1.03	53.7	10.7	2.51
	26.5	7.80	6.03	10.000	.576	.345	17.7	3.54	1.51	1.02	48.0	9.60	2.48
ST 6 WF	25	7.36	6.10	8.077	.641	.371	18.7	3.80	1.60	1.17	28.2	6.98	1.96
	22.5	6.62	6.03	8.042	.576	.336	16.6	3.40	1.59	1.13	25.0	6.20	1.94
	20	5.89	5.97	8.000	.516	.294	14.4	2.94	1.56	1.08	22.0	5.50	1.94
ST 6 WF	18	5.29	6.12	6.565	.540	.305	15.3	3.14	1.70	1.26	11.9	3.62	1.50
	15.5	4.56	6.04	6.525	.465	.265	13.0	2.69	1.69	1.22	9.9	3.04	1.47
	13.5	3.98	5.98	6.500	.400	.240	11.4	2.39	1.69	1.21	8.3	2.55	1.44

See page 10 for method of designation.

REGULAR SERIES



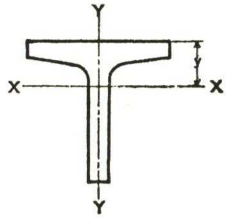
STRUCTURAL TEES
CUT FROM WF BEAMS
DIMENSIONS AND
PROPERTIES FOR DESIGNING

Section Number	Weight per Foot	Area	Depth of Tee	Flange		Stem Thickness	AXIS X-X				AXIS Y-Y		
				Width	Average Thickness		I	S	r	y	I	S	r
	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.	In.⁴	In.³	In.
ST 5 WF	56	16.46	5.69	10.415	1.248	.755	28.8	6.42	1.32	1.21	117.7	22.6	2.67
	50	14.72	5.56	10.345	1.118	.685	24.8	5.62	1.30	1.14	103.3	20.0	2.65
	44.5	13.09	5.44	10.275	.998	.615	21.3	4.88	1.28	1.07	90.3	17.6	2.63
	38.5	11.33	5.31	10.195	.868	.535	17.7	4.10	1.25	1.00	76.7	15.1	2.60
	36	10.59	5.25	10.170	.808	.510	16.4	3.83	1.24	.97	70.9	13.9	2.59
	33	9.70	5.19	10.117	.748	.457	14.5	3.39	1.22	.92	64.6	12.8	2.58
	30	8.83	5.13	10.075	.683	.415	12.8	3.02	1.21	.88	58.2	11.6	2.57
	27	7.94	5.06	10.028	.618	.368	11.2	2.64	1.18	.84	51.95	10.4	2.56
	24.5	7.20	5.00	10.000	.558	.340	10.1	2.40	1.18	.81	46.5	9.30	2.54
ST 5 WF	22.5	6.62	5.06	8.022	.618	.350	10.3	2.48	1.25	.91	26.6	6.63	2.00
	19.5	5.74	4.97	7.990	.528	.318	8.96	2.19	1.25	.88	22.5	5.62	1.98
	16.5	4.85	4.88	7.964	.433	.292	7.80	1.95	1.27	.88	18.2	4.58	1.94
ST 5 WF	14.5	4.27	5.11	5.799	.500	.289	8.38	2.07	1.40	1.05	7.61	2.62	1.34
	12.5	3.67	5.04	5.762	.430	.252	7.12	1.77	1.39	1.02	6.34	2.20	1.31
	10.5	3.10	4.95	5.750	.340	.240	6.31	1.62	1.43	1.06	4.87	1.69	1.25
ST 4 WF	33.5	9.85	4.50	8.287	.933	.575	10.94	3.07	1.05	.94	44.3	10.7	2.12
	29	8.53	4.38	8.222	.808	.510	9.11	2.60	1.03	.87	37.5	9.10	2.10
	24	7.06	4.25	8.117	.683	.405	6.92	2.00	.99	.78	30.45	7.50	2.08
	20	5.88	4.13	8.077	.558	.365	5.80	1.71	.99	.74	24.5	6.05	2.04
	17.5	5.15	4.06	8.027	.493	.315	4.88	1.45	.97	.69	21.25	5.30	2.03
	15.5	4.56	4.00	8.000	.433	.288	4.31	1.30	.97	.67	18.5	4.60	2.01
ST 4 WF	14	4.11	4.03	6.540	.463	.285	4.22	1.28	1.01	.73	10.8	3.30	1.62
	12	3.53	3.97	6.500	.398	.245	3.53	1.08	1.00	.70	9.10	2.80	1.61
ST 4 WF	10	2.94	4.07	5.268	.378	.248	3.66	1.13	1.12	.83	4.25	1.61	1.20
	8.5	2.50	4.00	5.250	.308	.230	3.21	1.01	1.13	.84	3.36	1.28	1.16

See page 10 for method of designation.

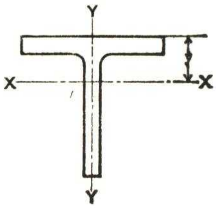
STRUCTURAL TEES

CUT FROM STANDARD BEAMS
DIMENSIONS AND
PROPERTIES FOR DESIGNING



Section Number	Weight per Foot	Area	Depth of Tee	Flange		Stem Thickness	Axis X-X				Axis Y-Y		
				Width	Average Thickness		I	S	r	y	I	S	r
	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.	In.⁴	In.³	In.
ST 6 I	25	7.29	6.00	5.477	.660	.687	25.2	6.05	1.85	1.84	7.85	2.87	1.03
	20.4	5.92	6.00	5.250	.660	.460	18.8	4.26	1.77	1.57	6.77	2.58	1.06
ST 6 I	17.5	5.10	6.00	5.078	.544	.428	17.2	3.95	1.83	1.65	4.93	1.94	.98
	15.9	4.63	6.00	5.000	.544	.350	14.9	3.31	1.78	1.51	4.68	1.87	1.00
ST 5 I	17.5	5.11	5.00	4.944	.491	.594	12.5	3.63	1.56	1.56	4.18	1.69	.90
	12.7	3.69	5.00	4.660	.491	.310	7.81	2.05	1.45	1.20	3.39	1.46	.95
ST 4 I	11.5	3.36	4.00	4.171	.425	.441	5.03	1.77	1.22	1.15	2.15	1.03	.80
	9.2	2.67	4.00	4.000	.425	.270	3.50	1.14	1.14	.94	1.86	.93	.83
ST 3.5 I	10	2.92	3.50	3.860	.392	.450	3.36	1.36	1.07	1.04	1.58	.82	.73
	7.65	2.22	3.50	3.660	.392	.250	2.18	.81	.99	.81	1.32	.72	.77
ST 3 I	8.625	2.51	3.00	3.565	.359	.465	2.13	1.02	.92	.91	1.15	.65	.67
	6.25	1.81	3.00	3.330	.359	.230	1.27	.55	.83	.69	.93	.56	.71

See page 10 for method of designation.

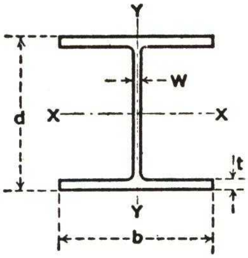


STRUCTURAL TEES
CUT FROM MISCELLANEOUS BEAMS

DIMENSIONS AND PROPERTIES FOR DESIGNING

Section Number	Weight per Foot	Area of Section	Depth of Tee	Flange		Stem Thickness	AXIS X-X				AXIS Y-Y		
				Width	Average Thickness		I	S	r	y	I	S	r
	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.	In.⁴	In.³	In.
MISCELLANEOUS													
ST 6 B	11.00	3.24	6.16	4.030	.424	.260	11.7	2.58	1.90	1.63	2.27	1.13	.84
	9.5	2.81	6.08	4.010	.349	.240	10.2	2.32	1.91	1.67	1.84	.92	.81
	8.25	2.43	6.00	4.000	.269	.230	9.02	2.13	1.93	1.76	1.39	.70	.76
	7.0	2.07	5.96	3.970	.224	.200	7.70	1.83	1.92	1.76	1.13	.57	.74
ST 5 B	9.5	2.80	5.13	4.020	.394	.250	6.70	1.74	1.55	1.28	2.09	1.04	.86
	8.5	2.49	5.06	4.010	.329	.240	6.07	1.62	1.56	1.32	1.73	.86	.83
	7.5	2.20	5.00	4.000	.269	.230	5.46	1.50	1.57	1.37	1.39	.70	.80
ST 5 B	5.75	1.69	4.94	3.950	.204	.180	4.15	1.16	1.57	1.35	1.00	.51	.77
ST 4 B	7.50	2.22	4.06	4.015	.314	.245	3.29	1.07	1.22	1.00	1.65	.82	.86
	6.50	1.91	4.00	4.000	.254	.230	2.90	.98	1.23	1.03	1.31	.66	.83
ST 4 B	5.00	1.48	3.95	3.940	.204	.170	2.15	.72	1.21	.96	1.00	.51	.82
ST 3 B	8.00	2.36	3.13	4.030	.404	.260	1.66	.68	.84	.67	2.16	1.07	.96
	6.00	1.77	3.00	4.000	.279	.230	1.30	.56	.86	.67	1.44	.72	.90
ST 3 B	4.25	1.25	2.92	3.940	.194	.170	.90	.40	.85	.64	.94	.48	.87
JUNIOR													
ST 6 Jr.	5.90	1.72	6.00	3.06	.225	.175	6.59	1.60	1.96	1.88	.49	.32	.53
ST 5 Jr.	4.50	1.32	5.00	2.69	.206	.155	3.46	.99	1.62	1.53	.30	.23	.48
ST 4 Jr.	3.25	.96	4.00	2.28	.189	.135	1.59	.56	1.29	1.18	.17	.15	.42
ST 3 Jr.	2.20	.65	3.00	1.84	.171	.114	.58	.27	.95	.84	.082	.089	.36

See page 10 for method of designation.
See pages 24-26 for mills supplying.



H BEARING PILES

DIMENSIONS AND PROPERTIES FOR DESIGNING

Section Number and Nominal Size	Weight per Foot	Area A	Depth d	Flange Width b	Flange Thickness t	Web Thickness W	Axis X-X I	Axis X-X S	Axis X-X r	Axis Y-Y I′	Axis Y-Y S′	Axis Y-Y r′
	Lb.	In.^{2}	In.	In.	In.	In.	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.
	117	34.44	14.234	14.885	.805	.805	1228.5	172.6	5.97	443.1	59.5	3.59
BP 14	102	30.01	14.032	14.784	.704	.704	1055.1	150.4	5.93	379.6	51.3	3.56
14x14½	89	26.19	13.856	14.696	.616	.616	909.1	131.2	5.89	326.2	44.4	3.53
	73	21.46	13.636	14.586	.506	.506	733.1	107.5	5.85	261.9	35.9	3.49
BP 12	74	21.76	12.122	12.217	.607	.607	566.5	93.5	5.10	184.7	30.2	2.91
12 x 12	53	15.58	11.780	12.046	.436	.436	394.8	67.0	5.03	127.3	21.2	2.86
BP 10	57	16.76	10.012	10.224	.564	.564	294.7	58.9	4.19	100.6	19.7	2.45
10 x 10	42	12.35	9.720	10.078	.418	.418	210.8	43.4	4.13	71.4	14.2	2.40
BP 8 8 x 8	36	10.60	8.026	8.158	.446	.446	119.8	29.9	3.36	40.4	9.9	1.95

SPECIAL SERIES SHAPES

PAGES 48-55

Under the grouping "Special" Shapes are shown sizes and shapes for which there is a fluctuating demand and which, therefore, are rolled at irregular intervals, and then only by special arrangement. Consequently the use of "Special" Shapes should generally be avoided, unless the quantity of any one size is sufficient to warrant a rolling.

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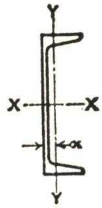
CHANNELS

CARBUILDING AND SHIPBUILDING

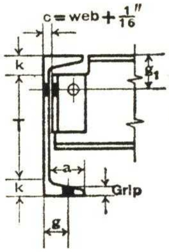
PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area	Depth	Flange		Web Thickness	AXIS X-X			AXIS Y-Y			
				Width	Average Thickness		I	S	r	I	S	r	x
In.	Lb.	In.^{2}	In.	In.	In.	In.	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.	In.
13 x 4	50.0	14.66	13.00	4.412	.610	.787	312.9	48.1	4.62	16.7	4.9	1.07	.98
	40.0	11.71	13.00	4.185	.610	.560	271.4	41.7	4.82	13.9	4.3	1.09	.97
	35.0	10.24	13.00	4.072	.610	.447	250.7	38.6	4.95	12.5	4.0	1.10	.99
	31.8	9.30	13.00	4.000	.610	.375	237.5	36.5	5.05	11.6	3.9	1.11	1.01
12 x 4	50.0	14.64	12.00	4.135	.700	.835	267.9	44.6	4.28	17.8	5.8	1.10	1.06
	45.0	13.24	12.00	4.000	.700	.700	248.4	41.4	4.37	16.0	5.4	1.11	1.05
	40.0	11.70	12.00	3.890	.700	.590	232.6	38.8	4.46	14.5	5.1	1.11	1.05
	35.0	10.22	12.00	3.767	.700	.467	214.9	35.8	4.58	12.9	4.8	1.12	1.07
12 x 3½	37.0	10.80	12.00	3.600	.600	.600	203.4	33.9	4.34	10.3	3.8	.98	.89
	32.9	9.60	12.00	3.500	.600	.500	189.0	31.5	4.44	9.4	3.6	.99	.89
	30.9	9.00	12.00	3.450	.600	.450	181.8	30.3	4.50	8.9	3.5	.99	.90
10 x 4	41.1	12.06	10.00	4.319	.575	.794	156.3	31.3	3.61	16.4	5.1	1.17	1.11
	33.6	9.80	10.00	4.100	.575	.575	138.0	27.6	3.75	13.7	4.6	1.18	1.11
	28.5	8.30	10.00	3.950	.575	.425	125.5	25.1	3.89	11.8	4.2	1.19	1.15
10 x 3½	28.3	8.23	10.00	3.500	.575	.475	116.9	23.4	3.77	8.6	3.4	1.02	.96
	24.9	7.23	10.00	3.400	.575	.375	108.6	21.7	3.88	7.6	3.2	1.03	.98
10 x 3½	25.3	7.38	10.00	3.550	.500	.425	106.0	21.2	3.79	7.9	3.0	1.04	.94
	21.9	6.38	10.00	3.450	.500	.325	97.6	19.5	3.91	7.0	2.8	1.05	.98
9 x 3½	25.4	7.41	9.00	3.500	.550	.450	87.3	19.4	3.43	8.0	3.2	1.04	1.00
	23.9	6.96	9.00	3.450	.550	.400	84.3	18.7	3.48	7.5	3.1	1.04	1.01
8 x 3½	22.8	6.63	8.00	3.500	.525	.425	63.3	15.8	3.09	7.4	3.0	1.05	1.04
	21.4	6.23	8.00	3.450	.525	.375	61.2	15.3	3.13	6.9	2.9	1.05	1.05
8 x 3	20.0	5.83	8.00	3.025	.500	.400	54.0	13.5	3.05	4.7	2.2	.90	.86
	18.7	5.43	8.00	2.975	.500	.350	51.9	13.0	3.09	4.4	2.1	.90	.88

For complete list of Carbuilding and Shipbuilding Channels, see catalogs of the various mills.
See page 10 for method of designation.

SPECIAL SERIES



CHANNELS

CARBUILDING AND SHIPBUILDING

DIMENSIONS FOR DETAILING

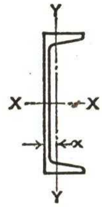
Depth of Section	Weight per Foot	Flange		Web		Distance					Grip	Max. Flange Rivet	Usual Gage g
		Width	Mean Thickness	Thickness	Half Thickness	a	T	k	g_1	c			
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
13	50.0	4 3/8	5/8	13/16	7/16	3 5/8	10 3/8	1 5/16	2 3/4	7/8	5/8	1	2 1/2
	40.0	4 1/8	5/8	9/16	5/16	3 5/8	10 3/8	1 5/16	2 3/4	5/8	5/8	1	2 1/2
	35.0	4 1/8	5/8	7/16	1/4	3 5/8	10 3/8	1 5/16	2 3/4	1/2	9/16	1	2 1/2
	31.8	4	5/8	3/8	3/16	3 5/8	10 3/8	1 5/16	2 3/4	7/16	9/16	1	2 1/2
12	50.0	4 1/8	11/16	7/8	7/16	3 3/8	9 1/2	1 1/4	2 1/2	15/16	11/16	1	2 1/2
	45.0	4	11/16	11/16	3/8	3 3/8	9 1/2	1 1/4	2 1/2	3/4	11/16	1	2 1/2
	40.0	3 7/8	11/16	5/8	5/16	3 3/8	9 1/2	1 1/4	2 1/2	11/16	11/16	1	2 1/2
	35.0	3 3/4	11/16	1/2	1/4	3 3/8	9 1/2	1 1/4	2 1/2	9/16	11/16	1	2 1/2
12	37.0	3 5/8	5/8	5/8	5/16	3	9 1/2	1 1/4	2 1/2	11/16	5/8	7/8	2 1/4
	32.9	3 1/2	5/8	1/2	1/4	3	9 1/2	1 1/4	2 1/2	9/16	9/16	7/8	2 1/4
	30.9	3 1/2	5/8	7/16	1/4	3	9 1/2	1 1/4	2 1/2	1/2	9/16	7/8	2 1/4
10	41.1	4 5/16	9/16	13/16	7/16	3 1/2	7 5/8	1 3/16	2 1/2	7/8	9/16	7/8	2
	33.6	4 1/8	9/16	9/16	5/16	3 1/2	7 5/8	1 3/16	2 1/2	5/8	9/16	7/8	2
	28.5	4	9/16	7/16	1/4	3 1/2	7 5/8	1 3/16	2 1/2	1/2	9/16	7/8	2
10	28.3	3 1/2	9/16	1/2	1/4	3	7 5/8	1 3/16	2 1/2	9/16	9/16	7/8	2
	24.9	3 3/8	9/16	3/8	3/16	3	7 5/8	1 3/16	2 1/2	7/16	9/16	7/8	2
10	25.3	3 1/2	1/2	7/16	1/4	3 1/8	7 7/8	1 1/16	2 1/2	1/2	1/2	7/8	2
	21.9	3 1/2	1/2	5/16	3/16	3 1/8	7 7/8	1 1/16	2 1/2	3/8	1/2	7/8	2
9	25.4	3 1/2	9/16	7/16	1/4	3	6 3/4	1 1/8	2 1/2	1/2	9/16	7/8	2
	23.9	3 1/2	9/16	7/16	3/16	3	6 3/4	1 1/8	2 1/2	1/2	9/16	7/8	2
8	22.8	3 1/2	1/2	7/16	1/4	3 1/8	5 7/8	1 1/16	2 1/4	1/2	1/2	7/8	2
	21.4	3 1/2	1/2	3/8	3/16	3 1/8	5 7/8	1 1/16	2 1/4	7/16	1/2	7/8	2
8	20.0	3	1/2	7/16	1/4	2 5/8	5 7/8	1 1/16	2 1/4	1/2	1/2	7/8	2
	18.7	3	1/2	3/8	3/16	2 5/8	5 7/8	1 1/16	2 1/4	7/16	1/2	7/8	2

Gage g_1 is based on k + 1¼", to nearest ¼".

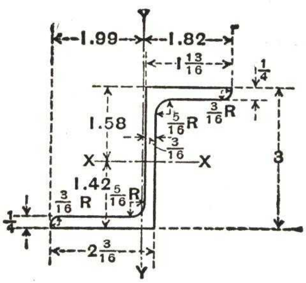
CHANNELS

CARBUILDING AND SHIPBUILDING

PROPERTIES FOR DESIGNING

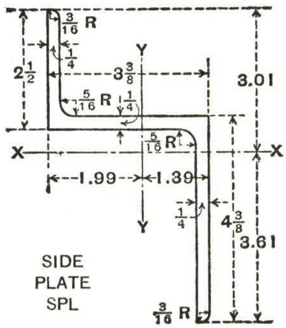


Nominal Size	Weight per Foot	Area	Depth	Flange Width	Flange Average Thick-ness	Web Thick-ness	Axis X-X I	Axis X-X S	Axis X-X r	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r	Axis Y-Y x
In.	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.⁴	In.³	In.	In.
7 x 3½	22.7	6.60	7.00	3.600	.500	.500	47.1	13.5	2.67	7.5	3.0	1.07	1.07
	19.1	5.55	7.00	3.450	.500	.350	42.8	12.2	2.78	6.3	2.7	1.07	1.11
7 x 3	17.6	5.12	7.00	3.000	.475	.375	37.3	10.7	2.70	4.2	2.0	.90	.90
6 x 3½	18.0	5.22	6.00	3.500	.475	.375	29.4	9.8	2.38	6.1	2.6	1.08	1.15
6 x 3½	15.3	4.47	6.00	3.500	.385	.340	25.3	8.4	2.38	5.1	2.1	1.07	1.08
6 x 3	16.3	4.75	6.00	3.000	.475	.375	25.8	8.6	2.33	4.0	1.9	.91	.95
	15.1	4.37	6.00	2.938	.475	.313	24.7	8.2	2.38	3.6	1.8	.91	.97
6 x 2½	12.0	3.52	6.00	2.500	.375	.313	18.6	6.2	2.30	2.0	1.1	.75	.72
‡4 x 2½	13.8	4.00	4.00	2.500	.500	.500	8.8	4.4	1.49	2.2	1.4	.74	.86
3 x 1⅞	9.0	2.64	3.00	2.125	.351	.500	3.1	2.1	1.09	.97	.68	.61	.70
	7.1	2.08	3.00	1.938	.351	.312	2.7	1.8	1.14	.71	.56	.59	.67



SIDE POST SP

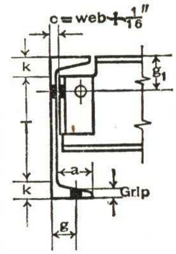
SPECIAL CAR BUILDING SHAPES



SIDE PLATE SPL

Symbol	Depth	Weight per Foot	Area	Axis X-X I	Axis X-X S	Axis X-X r	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r
	In.	Lb.	In.²	In.⁴	In.³	In.	In.⁴	In.³	In.
HCS	13 1/16	51.2	15.06	373.66	55.79	4.98	71.02	11.16	2.17
	12 15/16	41.2	12.12	313.02	47.51	5.08	59.14	9.41	2.21
	12⅞	36.21	10.65	276.10	42.75	5.09	51.38	8.17	2.20
	12 13/16	31.3	9.20	240.97	37.08	5.12	43.76	6.94	2.18
SP	3	5.10	1.50	2.13	1.34	1.19	1.16	0.58	0.88
SPL	3⅜	8.30	2.44	6.53	1.81	1.64	4.48	2.25	1.36
WSPL	7 7/16	9.9	2.89	11.26	2.70	1.97	6.94	2.34	1.55

‡Rolled by United States Steel Corp.



CHANNELS

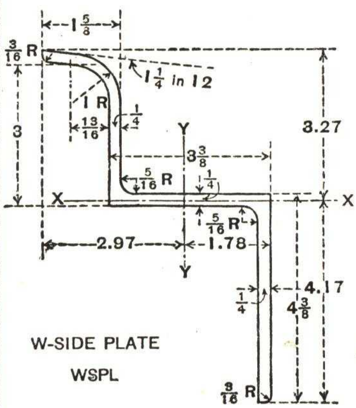
CARBUILDING AND SHIPBUILDING

DIMENSIONS FOR DETAILING

Depth of Section	Weight per Foot	Flange Width	Flange Mean Thickness	Web Thickness	Web Half Thickness	Distance a	Distance T	Distance k	Distance g_1	Distance c	Grip	Max. Flange Rivet	Usual Gage g
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
7	22.7	3⅝	½	½	¼	3⅛	4⅞	1 1/16	2¼	9/16	½	⅞	2
	19.1	3½	½	⅜	3/16	3⅛	4⅞	1 1/16	2¼	7/16	½	⅞	2
7	17.6	3	15/32	⅜	3/16	2⅝	5	1	2¼	7/16	½	¾	1¾
6	18.0	3½	½	⅜	3/16	3⅛	4	1	2¼	7/16	½	⅞	2
	15.3	3½	⅜	⅜	3/16	3⅛	4⅜	13/16	2	7/16	⅜	⅞	2
6	16.3	3	½	⅜	3/16	2⅝	4	1	2¼	7/16	½	¾	1¾
	15.1	3	½	5/16	3/16	2⅝	4	1	2¼	⅜	½	¾	1¾
6	12.0	2½	⅜	5/16	3/16	2⅛	4½	¾	2	⅜	⅜	⅝	1½
4	13.8	2½	½	½	¼	2	2⅜	13/16	2	9/16	½	⅝	1½
3	9.0	2⅛	⅜	½	¼	1⅝	1⅞	9/16		9/16			
	7.1	2	⅜	5/16	3/16	1⅝	1⅞	9/16		⅜			

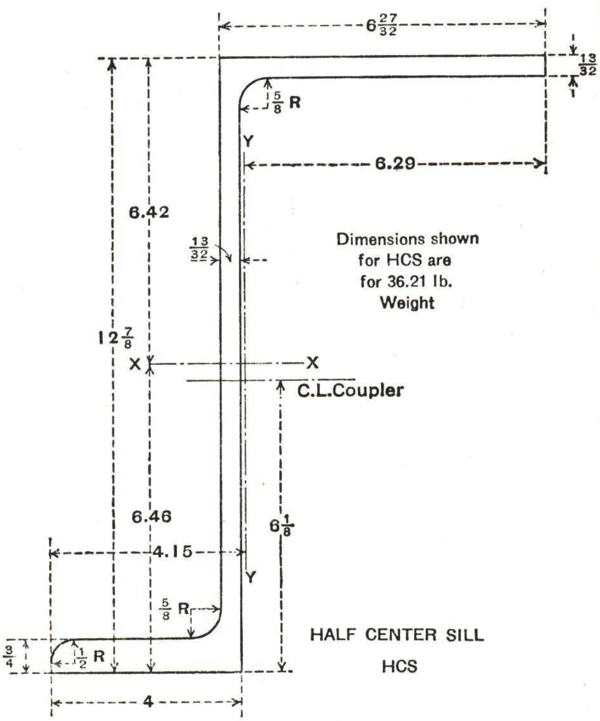
SPECIAL CARBUILDING SHAPES

(Properties on Page 50)



W-SIDE PLATE

WSPL



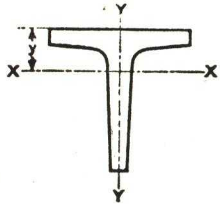
Dimensions shown for HCS are for 36.21 lb. Weight

HALF CENTER SILL

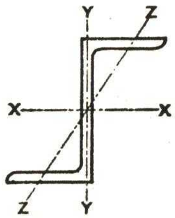
HCS

TEES

DIMENSIONS AND PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area	DIMENSIONS		Minimum Thickness		AXIS X-X				AXIS Y-Y		
			Depth	Width of Flange	Flange	Stem	I	S	r	y	I	S	r
In.	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.	In.⁴	In.³	In.
5 x 3 1/8	13.6	4.00	3 1/8	5	1/2	13/32	2.7	1.1	.82	.76	5.2	2.1	1.14
5 x 3	11.5	3.37	3	5	3/8	13/32	2.4	1.1	.84	.76	3.9	1.6	1.10
4 x 4 1/2	11.2	3.29	4 1/2	4	3/8	3/8	6.3	2.0	1.39	1.31	2.1	1.1	.80
4 x 4	13.5	3.97	4	4	1/2	1/2	5.7	2.0	1.20	1.18	2.8	1.4	.84
4 x 3	9.2	2.68	3	4	3/8	3/8	2.0	.90	.86	.78	2.1	1.1	.89
4 x 2 1/2	8.5	2.48	2 1/2	4	3/8	3/8	1.2	.62	.69	.62	2.1	1.0	.92
3 x 3	7.8	2.29	3	3	3/8	3/8	1.84	.86	.89	.88	.89	.60	.63
3 x 3	6.7	1.97	3	3	5/16	5/16	1.61	.74	.90	.85	.75	.50	.62
3 x 2 1/2	6.1	1.77	2 1/2	3	5/16	5/16	.94	.51	.73	.68	.75	.50	.65
2 1/2x2 1/2	6.4	1.87	2 1/2	2 1/2	3/8	3/8	1.0	.59	.74	.76	.52	.42	.53
2 1/2x2 1/2	4.6	1.33	2 1/2	2 1/2	1/4	1/4	.74	.42	.75	.71	.34	.27	.51
2 1/4x2 1/4	4.1	1.19	2 1/4	2 1/4	1/4	1/4	.52	.32	.66	.65	.25	.22	.46
2 x 2	4.3	1.26	2	2	5/16	5/16	.44	.31	.59	.61	.23	.23	.43
2 x 2	3.56	1.05	2	2	1/4	1/4	.37	.26	.59	.59	.18	.18	.42



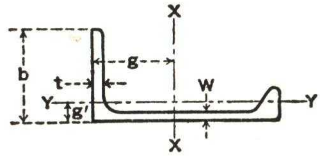
ZEES

DIMENSIONS
AND
PROPERTIES FOR DESIGNING

Nominal Size	Weight per Foot	Area	DIMENSIONS			AXIS X-X			AXIS Y-Y			AXIS Z-Z
			Depth	Width of Flange	Thickness	I	S	r	I	S	r	r
In.	Lb.	In.^{2}	In.	In.	In.	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.	In.
6 x $3\frac{1}{2}$	21.1	6.19	$6\frac{1}{8}$	$3\frac{5}{8}$	$\frac{1}{2}$	34.4	11.2	2.36	12.9	3.8	1.44	.84
	15.7	4.59	6	$3\frac{1}{2}$	$\frac{3}{8}$	25.3	8.4	2.35	9.1	2.8	1.41	.83
5 x $3\frac{1}{4}$	17.9	5.25	5	$3\frac{1}{4}$	$\frac{1}{2}$	19.2	7.7	1.91	9.1	3.0	1.31	.74
	16.4	4.81	$5\frac{1}{8}$	$3\frac{3}{8}$	$\frac{7}{16}$	19.1	7.4	1.99	9.2	2.9	1.38	.77
	14.0	4.10	$5\frac{1}{16}$	$3\frac{5}{16}$	$\frac{3}{8}$	16.2	6.4	1.99	7.7	2.5	1.37	.76
	11.6	3.40	5	$3\frac{1}{4}$	$\frac{5}{16}$	13.4	5.3	1.98	6.2	2.0	1.35	.75
4 x 3	15.9	4.66	$4\frac{1}{16}$	$3\frac{1}{8}$	$\frac{1}{2}$	11.2	5.5	1.55	8.0	2.8	1.31	.67
	12.5	3.66	$4\frac{1}{8}$	$3\frac{3}{16}$	$\frac{3}{8}$	9.6	4.7	1.62	6.8	2.3	1.36	.69
	10.3	3.03	$4\frac{1}{16}$	$3\frac{1}{8}$	$\frac{5}{16}$	7.9	3.9	1.62	5.5	1.8	1.34	.68
	8.2	2.41	4	$3\frac{1}{16}$	$\frac{1}{4}$	6.3	3.1	1.62	4.2	1.4	1.33	.67
3 x $2\frac{3}{4}$	12.6	3.69	3	$2\frac{11}{16}$	$\frac{1}{2}$	4.6	3.1	1.12	4.9	2.0	1.15	.53
	9.8	2.86	3	$2\frac{11}{16}$	$\frac{3}{8}$	3.9	2.6	1.16	3.9	1.6	1.17	.54
	6.7	1.97	3	$2\frac{11}{16}$	$\frac{1}{4}$	2.9	1.9	1.21	2.8	1.1	1.19	.55

Tees and Zees are seldom used as structural framing members. When so used they are generally employed on short spans in flexure.

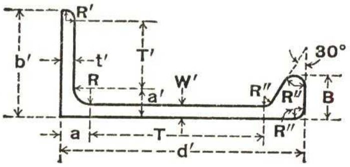
BULB ANGLES



PROPERTIES FOR DESIGNING

Nominal Size	Weight per Foot	Area	Flange Thickness t	Flange Width b	Web Thickness W	Axis X-X I	Axis X-X S	Axis X-X r	Axis X-X g	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r	Axis Y-Y g'
In.	Lb.	In.^{2}	In.	In.	In.	In.^{4}	In.^{3}	In.	In.	In.^{4}	In.^{3}	In.	In.
SHIPBUILDING TYPE													
10 x 3½	32.3	9.49	.61	3.69	.64	118.1	22.1	3.53	4.69	6.2	2.2	0.81	0.77
	29.9	8.78	.58	3.63	.58	110.7	20.9	3.55	4.70	5.6	2.0	0.80	0.75
	27.2	7.98	.485	3.57	.52	102.9	19.6	3.59	4.80	5.1	1.8	0.80	0.72
	24.8	7.28	.455	3.51	.46	95.4	18.4	3.62	4.82	4.6	1.6	0.80	0.70
	22.4	6.57	.425	3.45	.40	88.0	17.2	3.66	4.85	4.1	1.5	0.79	0.68
9 x 3½	23.8	7.00	.465	3.57	.50	73.3	15.1	3.24	4.19	4.7	1.7	0.82	0.72
	21.6	6.35	.435	3.51	.44	67.7	14.1	3.27	4.21	4.2	1.5	0.82	0.70
	19.4	5.70	.405	3.45	.38	62.2	13.1	3.30	4.22	3.7	1.4	0.81	0.68
8 x 3½	24.3	7.14	.55	3.68	.58	57.0	12.7	2.83	3.53	5.2	1.9	0.85	0.78
	20.0	5.87	.43	3.56	.46	48.9	11.1	2.89	3.61	4.2	1.5	0.85	0.72
	16.0	4.70	.37	3.44	.34	40.9	9.4	2.95	3.62	3.3	1.2	0.84	0.69
7 x 3½	21.1	6.19	.54	3.68	.56	37.5	9.2	2.46	2.95	4.8	1.8	0.88	0.80
	17.1	5.03	.41	3.56	.44	32.0	8.0	2.52	3.03	3.9	1.4	0.88	0.74
	13.6	3.98	.35	3.44	.32	26.4	6.7	2.58	3.01	3.0	1.1	0.87	0.71
6 x 3½	17.4	5.12	.49	3.69	.52	22.7	6.3	2.10	2.42	4.3	1.6	0.92	0.82
	13.9	4.06	.365	3.57	.40	19.0	5.3	2.16	2.47	3.4	1.2	0.91	0.76
	10.7	3.13	.305	3.45	.28	15.3	4.4	2.21	2.45	2.6	0.94	0.91	0.73
5 x 2½	9.8	2.88	.33	2.56	.36	9.1	3.1	1.78	2.06	1.1	0.56	0.63	0.55
	7.3	2.13	.27	2.44	.24	7.1	2.4	1.83	2.01	0.81	0.42	0.62	0.51
3 x 2	3.8	1.12	.19	2.00	.19	1.3	0.74	1.09	1.24	0.31	0.20	0.54	0.45
CARBUILDING TYPE													
5 x 4½	19.1	5.64	.44	4.50	.44	20.7	7.9	1.92	2.38	8.0	2.4	1.19	1.19
5 x 3½	13.0	3.81	.38	3.50	.38	13.4	4.8	1.88	2.22	3.3	1.2	.93	.86
4 x 3½	14.3	4.20	.50	3.50	.50	8.7	3.7	1.44	1.65	3.8	1.5	.96	.99
4 x 3½	11.9	3.48	.38	3.50	.38	7.9	3.5	1.50	1.77	3.1	1.2	.94	.94

SPECIAL SERIES



BULB ANGLES

DIMENSIONS FOR DETAILING

SHIPBUILDING TYPE

Nominal Size	Weight per Foot	Flange Width (Nominal) b′	Flange Thickness (Nominal) t′	Web Depth (Nominal) d′	Web Thickness (Nominal) W′	Width of Bulb (Nominal) B	Tangents Web (Nominal) a	Tangents Web (Nominal) T	Tangents Flange (Nominal) a′	Tangents Flange (Nominal) T′	Radius of Fillet (Root) R	Radii of Roundings R′	Radii of Roundings R″
In.	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
10 x 3 1/2	32.3	3 3/4	5/8	10	5/8	1 15/16	1 1/8	7 3/8	1 3/16	2 1/4	.54	.27	.40
	29.9	3 5/8	9/16	10	9/16	1 7/8	1 1/8	7 3/8	1 1/8	2 1/4	.54	.27	.40
	27.2	3 5/8	1/2	10	1/2	1 13/16	1	7 3/8	1 1/16	2 1/4	.54	.27	.40
	24.8	3 1/2	7/16	10	7/16	1 3/4	1	7 3/8	1	2 1/4	.54	.27	.40
	22.4	3 1/2	7/16	10	3/8	1 11/16	15/16	7 3/8	15/16	2 1/4	.54	.27	.40
9 x 3 1/2	23.8	3 5/8	7/16	9	1/2	1 11/16	1	6 9/16	1 1/16	2 1/4	.54	.27	.36
	21.6	3 1/2	7/16	9	7/16	1 5/8	1	6 9/16	1	2 1/4	.54	.27	.36
	19.4	3 1/2	3/8	9	3/8	1 9/16	15/16	6 9/16	15/16	2 1/4	.54	.27	.36
8 x 3 1/2	24.3	3 5/8	9/16	8	9/16	1 5/8	1 1/16	5 3/4	1 1/8	2 5/16	.54	.27	.32
	20.0	3 1/2	7/16	8	7/16	1 1/2	1	5 3/4	1	2 5/16	.54	.27	.32
	16.0	3 1/2	3/8	8	5/16	1 3/8	15/16	5 3/4	7/8	2 5/16	.54	.27	.32
7 x 3 1/2	21.1	3 5/8	9/16	7	9/16	1 1/2	1 1/16	4 15/16	1 1/8	2 5/16	.54	.27	.28
	17.1	3 1/2	7/16	7	7/16	1 3/8	15/16	4 15/16	1	2 5/16	.54	.27	.28
	13.6	3 1/2	3/8	7	5/16	1 1/4	7/8	4 15/16	7/8	2 5/16	.54	.27	.28
6 x 3 1/2	17.4	3 3/4	1/2	6	1/2	1 5/16	1	4 3/16	1 1/16	2 3/8	.54	.27	.24
	13.9	3 5/8	3/8	6	3/8	1 3/16	7/8	4 3/16	15/16	2 3/8	.54	.27	.24
	10.7	3 1/2	5/16	6	1/4	1 1/16	7/8	4 3/16	13/16	2 3/8	.54	.27	.24
5 x 2 1/2	9.8	2 1/2	5/16	5	3/8	1	3/4	3 1/2	3/4	1 9/16	.42	.21	.20
	7.3	2 1/2	1/4	5	1/4	7/8	11/16	3 1/2	11/16	1 9/16	.42	.21	.20
3 x 2	3.8	2	3/16	3	3/16	9/16	3/8	1 13/16	3/8	1 1/2	.19	.125	.25

CARBUILDING TYPE

Nominal Size	Weight per Foot	Flange Width (Nominal) b′	Flange Thickness (Nominal) t′	Web Depth (Nominal) d′	Web Thickness (Nominal) W′	Width of Bulb (Nominal) B	Tangents Web (Nominal) a	Tangents Web (Nominal) T	Tangents Flange (Nominal) a′	Tangents Flange (Nominal) T′	Radius of Fillet (Root) R	Radii of Roundings R′	Radii of Roundings R″
5 x 4 1/2	19.1	4 1/2	7/16	5	7/16	2 1/4	13/16	2 9/16	13/16	3 5/16	3/8	3/8	1/2
5 x 3 1/2	13.0	3 1/2	3/8	5	3/8	1 1/2	3/4	3	3/4	2 7/16	3/8	5/16	3/8
4 x 3 1/2	14.3	3 1/2	1/2	4	1/2	1 1/2	7/8	1 7/8	7/8	2 5/16	3/8	5/16	3/8
4 x 3 1/2	11.9	3 1/2	3/8	4	3/8	1 1/2	3/4	1 31/32	3/4	2 7/16	3/8	5/16	3/8

BARS, PLATES
AND
ROLLED STEEL BEARING PLATES

BARS AND PLATES

Flat steel, in the thicknesses adapted to structural use, is classified as follows:

Bars..................6 inches or less in width, 13/64″ or over in thickness.
Plates...............Over 6 inches in width, 1/4″ and over in thickness.
Over 48 inches in width, 3/16″ and over in thickness.

Bars are available from many mills in all necessary thicknesses and lengths, in widths varying by half-inches and thicknesses varying by sixteenths of an inch.

Plates are further defined as "Universal Mill (U. M.) Plates" or "Sheared Plates", according as they are rolled to the specified width, with rolled longitudinal edges, or are sheared (sometimes, at the option of the producer, flame cut) to the ordered width from wider plates. When universal plates are required, the mill order must so state. U. M. plates are used for cover plates of columns and girders, for web plates, and where the appearance or the specifications require a finished edge.

Plate widths should vary by even inches, though 1/2 inch increments are obtainable; thicknesses by increments of 1/16 inch up to two inches, 1/8 inch over 2 inches to 6 inches, and 1/4 inch over 6 inches.

Plate mills are located in all districts, but the sizes of plates produced differ greatly and the catalogs of individual mills should be consulted for detail data. Tables on page 59 give, in condensed form, the lengths obtainable for various width ranges from the major producers, together with the number of mills from which such sizes may be obtained.

"Sketch Plates", exclusive of those with re-entrant cuts, can be supplied by most mills by shearing. Odd shapes in most instances require flame cutting, for which flame cutting extras are applicable. "Full Circles" are also available; either by shearing, up to 1 inch, or by flame cutting for heavier gauges. "Floor Plates—Raised Pattern", page 59, are rolled by only a few mills; which should be consulted concerning sizes and extras.

The base price of steel plates is applied without extras for thickness or size, to rectangular plates which fall within all of the following limits:

Thickness;	3/8 in. to and including 1 1/2 in.
Width;	(sheared mill product required) 24 in. to 90 in. incl.
	(" " " not ") 6 in. " 90 in. "
Length;	8 ft. and over, up to published limit of length but not over 60 ft.

Designs and details usually specify plates by thicknesses, but plates up to 2 inches are occasionally ordered by weight per foot. Plates over 2 inches thick must be ordered by thickness.

Standard practice is to invoice plates to the fabricator at actual scale weight at point of shipment. The allowable overweight which may be charged for is limited in accordance with the tables on pages 68 and 69 of this Manual.

All sketch plates, including circles, are invoiced at actual weight and are not subject to the same weight tolerance limits as apply to rectangular plates.

All plates ordered flame cut for whatever reason take extras for flame cutting in addition to all other extras. For example, rolled steel bearing plates are often flame cut to prevent distortion due to shearing and would also take the regular extra for the thickness involved.

Plates of Structural Steel for Bridges and Buildings, A.S.T.M. Designation A7, are sold at as low an extra for quality as any steel sold subject to physical test.

Extras for thickness, width, length, cutting, quality and quantity, which are added to the base price of plates, are subject to occasional revision, and should be obtained by inquiry of the producer; the foregoing general statements are made as a guide toward economy in design.

PLATES

TABLES OF AVAILABLE SIZES

Note to Tables I and II: The first length given is obtainable from most, and usually from all, of the mills rolling the given width. The second length given is the maximum obtainable from any mill, and such lengths are subject to substantial extras. For plates of large sizes, designers should consult fabricators regarding possibilities of fabrication, shipment and erection.

TABLE I

Length, in Feet, of Universal Mill Plates obtainable in the respective widths shown.

Thickness Inches	Width, Inches									
	6-12	13-20	21-26	27-30	31-36	37-42	43-46	47-48	49-58	59-60
¼	65-80	60-125	60-125	60-125	60-125	40-100	90-100	90-100	40- 65	60-
⅜	65-80	60-125	60-125	60-125	60-125	60-125	90-125	90-125	80- 90	70-
½	65-80	60-125	60-125	60-125	60-125	60-125	90-125	90-120	85-120	60-
¾	65-80	60-125	60-125	60-125	60-125	55-125	90-125	90-120	80-120	40-
1	65-80	60-125	60-125	60-125	60-125	40-125	90-125	90- 95	70- 95	40-
1¼	65-75	48-125	48-125	49-125	49-125	38-125	90-115	75- 90	60- 75	40-
1½	40-60	48-120	46-125	46-125	45-125	33-105	90- 95	65- 90	50- 65	35-
1¾	35-60	41-110	40-125	40-125	38-110	28- 90	80- 90	55- 90	45- 55	30-
2	30-60	36- 90	35-125	35-110	34- 95	24- 75	70- 90	45- 90	40- 45	25-
No. of mills from which obtainable	5	7	7	6	6	4	3	3	1	1

TABLE II

Length, in Feet, of Sheared Plates obtainable in the respective widths shown.

Thickness Inches	Width, Inches									
	24-36	37-48	49-60	61-78	79-96	97-114	115-132	133-150	151-168	169-186
¼	40-45	40-50	40-50	35-55	30-48	27-38	21-30			
⅜	38-50	40-70	40-70	35-70	30-65	30-52	26-48	17-30	24-	21-
½	36-50	40-70	40-70	35-70	30-70	30-55	36-50	20-37	33-	27-
¾	36-50	37-70	35-70	35-70	30-70	30-55	35-48	19-45	45-	39-
1	36-50	34-70	30-70	32-70	25-66	25-53	35-48	18-45	45-	41-
1¼	30-50	30-70	25-70	25-65	20-60	20-45	31-45	17-45	42-	38-
1½	25-40	30-70	23-60	21-60	16-56	15-45	30-45	16-42	41-	33-
1¾	25-40	30-60	22-52	18-59	14-50	12-45	28-44	15-42	40-	31-
2	20-35	25-55	20-49	16-52	13-47	11-45	24-43	14-42	39-	29-
No. of mills from which obtainable	14	14	14	12	12	11	9	5	1	1

FLOOR PLATES—RAISED PATTERN

Different mills offer floor plates in different styles, patterns and extreme dimensions. The nominal or ordered thickness is that of the flat plate exclusive of the height of the raised pattern. The usual weights are as follows:

Nominal Thickness Inches	⅛	3/16	¼	5/16	⅜	7/16	½	⅝	¾	⅞	1
Nominal Weight Lb. per sq. ft.	6.15	8.7	11.25	13.8	16.35	18.9	21.45	26.55	31.65	36.75	41.85

In general, lengths are limited to 10 feet for widths of 6 to 20 inches and 20 feet for widths of 20 to 72 inches. For longer or thicker plates, and for precise information on all the foregoing, the individual manufacturers should be consulted.

ROLLED STEEL BEARING PLATES

Rolled steel bearing plates are extensively used for column bases, wall bearing plates, and a variety of other uses.

Since standard sizes are kept in stock, and only simple fabrication is required, shipments can be made promptly.

The smaller and thinner bearing plates, up to and including 2 inches in thickness, are rolled flat and with surfaces sufficiently smooth to receive, without planing, the milled ends of column shafts. Bearing plates 4 inches and under in thickness can be straightened by a press to within the required limits of flatness.

Rolled steel bearing plates of thicknesses greater than 4 inches are likely to be slightly bowed or cambered so that, in order to provide proper bearing surfaces, these plates should be planed on their top surfaces directly under the columns. It will not be necessary to plane the bottom surfaces when the plates rest on concrete foundations, as full bearing contact can be provided with strong cement grout.

When plates over 4 inches thick rest on steel, the top surfaces should be planed for the column bearing and the bottom surfaces planed all over.

Sizes of rolled steel bearing plates required for use as wall bearing plates or column base plates can be determined by the methods given on pages 128 and 129. Allowable loads on column base plates are given on pages 249 to 251.

The tables of permissible variations of dimensions of the American Iron and Steel Institute, as given on page 69, Table III, should be consulted when ordering bearing plates for such finished dimensions as are required by the design.

STANDARD ROLLED SIZES

ALL DIMENSIONS IN INCHES

14 x 1¼	20 x 2	28 x 3	36 x 4	44 x 5	52 x 6	60 x 7	66 x 9	78 x 9
14 x 1½	20 x 2½	28 x 3½	36 x 4½	44 x 5½	52 x 6½	60 x 7½	72 x 8	78 x 9½
	20 x 3			44 x 6	52 x 7	60 x 8	72 x 8½	78 x 10
16 x 1½	24 x 2	32 x 3½	40 x 4½	48 x 5½	56 x 6½	66 x 7½	72 x 9	84 x 9½
16 x 2	24 x 2½	32 x 4	40 x 5	48 x 6	56 x 7	66 x 8	72 x 9½	84 x 10
	24 x 3			48 x 6½	56 x 8	66 x 8½	72 x 10	

SECTION MODULI OF BEARING PLATES 1 INCH WIDE FOR THICKNESSES GREATER THAN 1 INCH

Thickness In.	S In.³	Thickness In.	S In.³	Thickness In.	S In.³	Thickness In.	S In.³
1¼	.26	3¼	1.76	5¼	4.59	7¼	8.76
1½	.38	3½	2.04	5½	5.04	7½	9.38
1¾	.51	3¾	2.34	5¾	5.51	7¾	10.01
2	.67	4	2.67	6	6.00	8	10.67
2¼	.84	4¼	3.01	6¼	6.51	8¼	11.34
2½	1.04	4½	3.38	6½	7.04	8½	12.04
2¾	1.26	4¾	3.76	6¾	7.59	8¾	12.76
3	1.50	5	4.17	7	8.17	9	13.50

ROLLING MILL PRACTICE

METHODS OF SPREADING ROLLS

CAMBERING OF ROLLED BEAMS

ROLLING AND CUTTING TOLERANCES FOR ROLLED STEEL STRUCTURAL SHAPES

PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS OF ROLLED STEEL STRUCTURAL SHAPES AND PLATES

METHODS OF SPREADING ROLLS

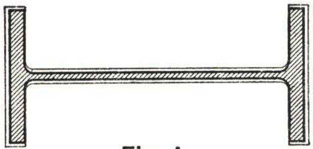


Fig. 1

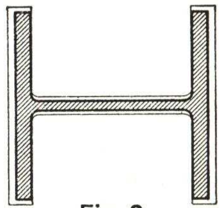


Fig. 2

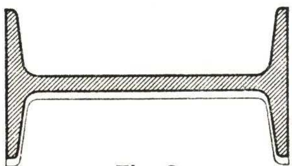


Fig. 3

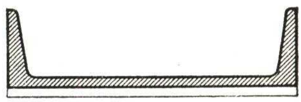


Fig. 4

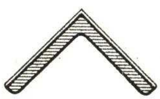


Fig. 5

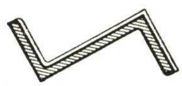


Fig. 6

Figures 1 and 2 illustrate the method of increasing the areas and weights of Wide Flange Shapes, whereby the thickness of both flange and web is changed with a corresponding change in the beam depth and flange width. The areas and weights of American Standard Beams and Channels are increased from the minimum as shown in Figures 3 and 4; an equal amount is added to the thickness of the web and to the width of the flange, all other dimensions remaining unchanged. As shown in Figure 5, the weights and areas of Angles are varied from the minimum by increasing the thickness of each leg, the length of the legs being slightly increased by so doing. Figure 6 illustrates the method of increasing the areas and weights of Zees. Rolls for Tees cannot be spread.

CAMBERING OF ROLLED BEAMS

The following information covers the limitations upon cold cambering of deep beams at the mill, as offered by the American mills which produce wide flange sections.

Maximum length for cambering is 100 feet.

Maximum camber measured at mid-length is shown in the table below. Conversely, this table may be read to give the minimum length for a given camber.

Section	Maximum Camber for Given Length												
	25′	30′	35′	40′	45′	50′	55′	60′	65′	70′	75′	80′	85′
24″ Wide Flange and Over		1″	1½″	2″	2½″	3″	3½″	3¾″	4″	4¼″	4½″	4¾″	5″
21″ Wide Flange 24″ Standard	1″	1½″	2″	2½″	3″	3½″	3¾″	4″	4¼″	4½″	4¾″	5″	

Camber will approximate a simple regular curve from end to end (nearly) of beam, or between any two points on beam as specified. Reverse or other compound curves will not be undertaken. Camber shall be specified by the ordinate at mid-length of the portion specified to be curved. Ordinates at other points shall not be specified. The camber ordinate is subject to a tolerance of nothing under to ½ in. over for a length 50 ft. and less; and for lengths over 50 ft., ⅛ in. is to be added to the over tolerance for each additional 10 ft. or fraction thereof.

Camber is secured by gagging beams cold. Extremely small cambers may not be permanent and the beam may lose camber due to the release of stresses put into the beam during the camber operation. Minimum camber likely to remain permanent is indicated in table below.

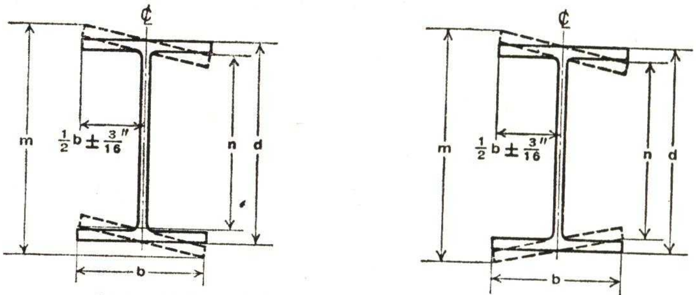
Wide Flange Sections	Minimum Camber Likely to Remain Permanent								
	30′ Length	35′ Length	40′ Length	45′ Length	50′ Length	55′ Length	65′ Length	75′ Length	85′ Length
36″	½″	½″	¾″	1″	1¼″	1½″	2¼″	3″	3¾″
33″	½″	¾″	1″	1¼″	1½″	1¾″	2½″	3¼″	4″
30″	½″	¾″	1″	1¼″	1½″	2″	2¾″	3½″	4½″
27″	¾″	1″	1″	1½″	1¾″	2″	3″	4″	5″
24″	¾″	1″	1¼″	1½″	2″	2½″	3¼″	4½″	5″

Wide Flange Sections and Standard Beams	Minimum Camber Likely to Remain Permanent								
	25′ Length	30′ Length	35′ Length	40′ Length	45′ Length	50′ Length	60′ Length	70′ Length	80′ Length
21″ WF	½″	¾″	1″	1½″	1¾″	2¼″	3¼″	4½″	5″
24″ Standard	½″	¾″	1″	1¼″	1½″	2″	2¾″	3¾″	5″

While cambers less than shown in this table can be furnished, no guarantee can be given with respect to their permanency.

ROLLING AND CUTTING TOLERANCES

WF SHAPES



Scale of Permissible Tolerances exaggerated for clarity.

ROLLING TOLERANCES

Nominal Depth	Depth d		Width of Flange b		Out of Square or Parallel	Maximum Depth at any Point	Web off Center
	+	−	+	−	m minus n	m	
Up to 12″ incl.	1/8″	1/8″	1/4″	3/16″	Not more than 3/16″	Not more than 1/4″ over theoretical	Not more than 3/16″
Over 12″	1/8″	1/8″	1/4″	3/16″	Not more than 1/4″	Not more than 1/4″ over theoretical	Not more than 3/16″

Shapes may have an allowable variation in weight of plus or minus 2½% from the nominal weight.

CUTTING TOLERANCES

Section	Length in feet: Up to 30 incl.		Length in feet: Over 30		Special Tolerances
	+	−	+	−	
Beams 8″ to 24″ incl.	3/8″	3/8″	3/8″ plus 1/16″ for each 5′ or fraction thereof above 30′	3/8″	When order specifies cutting tolerance "all plus, no minus" (no under-run) the tolerance applying to the ordered length shall be the arithmetical sum of the plus and minus tolerances given in this table.
Beams over 24″	1/2″	1/2″	1/2″ plus 1/16″ for each 5′ or fraction thereof above 30′	1/2″	
Columns all sizes	1/2″	1/2″	1/2″ plus 1/16″ for each 5′ or fraction thereof above 30′	1/2″	

Ends out of square: 1/64″ per inch of depth, or flange width if greater than depth.

Allowance for Milling: For material which is to be milled the order should show whether one or both ends are to be milled, allowance added for milling, and whether material is to be cut to standard or special tolerances given above.

It is recommended that material to be milled be ordered in the following lengths:

Milled one end only: Finished length plus 5/8″.
Milled both ends: Finished length plus 7/8″.

Straightness: Tolerances for beams: $\frac{1}{8}'' \times \frac{\text{total length in feet}}{10'}$

Where sections are specified on orders as columns, the following tolerances will apply:

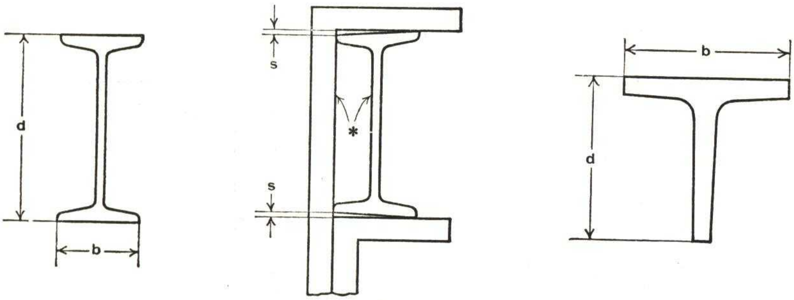
Lengths up to 45′ 0″: $\frac{1}{8}'' \times \frac{\text{total length in feet}}{10'}$ but not over 3/8″ max.

Lengths over 45′ 0″: $\frac{3}{8}'' + \frac{1}{8}'' \times \frac{\text{total length}-45'}{10'}$

ROLLING AND CUTTING TOLERANCES

AMERICAN STANDARD BEAMS AND TEES

STRUCTURAL SIZES



Scale of Permissible Tolerances exaggerated for clarity.

ROLLING TOLERANCES

Nominal Depth	Depth d +	Depth d −	Width of Flanges b +	Width of Flanges b −	Out of Square or Parallel s + s	Weight +	Weight −
3″ to 7″ incl.	3/32″	1/16″	1/8″	1/8″	1/32″ per inch of flange	2½%	2½%
Over 7″ to 14″ incl.	1/8″	3/32″	5/32″	5/32″		2½%	2½%
Over 14″ to 24″ incl.	3/16″	1/8″	3/16″	3/16″		2½%	2½%

CUTTING TOLERANCES

Section	Up to 30′ incl. Over	Up to 30′ incl. Under	Over 30′ to 40′ incl. Over	Over 30′ to 40′ incl. Under	Over 40′ to 50′ incl. Over	Over 40′ to 50′ incl. Under	Over 50′ Over	Over 50′ Under
Structural Beams	3/8″	3/8″	5/8″	3/8″	7/8″	3/8″	1″	3/8″
Structural Tees	3/4″	0	1″	0	1¼″	0	1¼″	0

Ends out of square: 1/64″ per inch of depth.

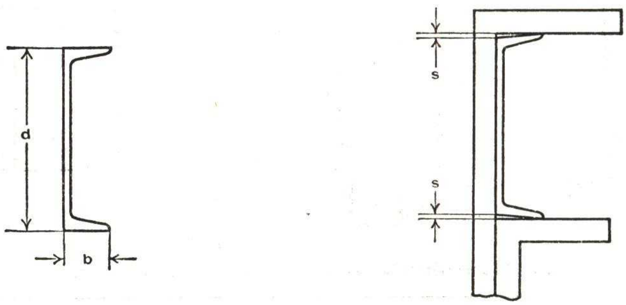
Camber tolerance: $\dfrac{\frac{1}{8}'' \times \text{total length in feet}}{5'}$

Weight tolerances are based on each shipment consisting of carload lots or fraction thereof of the same figured or ordered weight per linear foot.

*Back of square and web to be parallel when measuring for "out of square."

ROLLING AND CUTTING TOLERANCES

AMERICAN STANDARD CHANNELS
CARBUILDING AND SHIPBUILDING CHANNELS
(STRUCTURAL SIZES)



Scale of Permissible Tolerances exaggerated for clarity.

ROLLING TOLERANCES

Nominal Depth	Depth d		Width of Flanges b		Out of Square or Parallel	Weight	
	+	−	+	−	s + s	+	−
3″ to 7″ incl.	3/32″	1/16″	1/8″	1/8″	1/32″ per inch of flange	2½%	2½%
Over 7″ to 14″ incl.	1/8″	3/32″	1/8″	5/32″		2½%	2½%
Over 14″ to 18″ incl.	3/16″	1/8″	1/8″	3/16″		2½%	2½%

CUTTING TOLERANCES

Section	Up to 30′ incl.		Over 30′ to 40′ incl.		Over 40′ to 50′ incl.		Over 50′	
	Over	Under	Over	Under	Over	Under	Over	Under
Structural	3/8″	3/8″	5/8″	3/8″	7/8″	3/8″	1″	3/8″

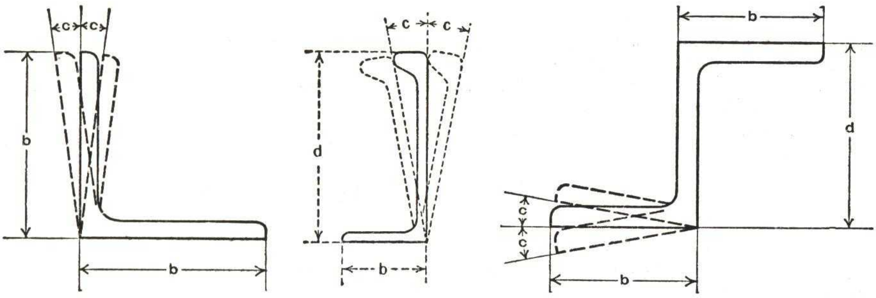
Ends out of square: 1/64″ per inch of depth.

Camber tolerance: $\dfrac{\frac{1}{8}'' \times \text{total length in feet}}{5'}$

Weight tolerances are based on each shipment consisting of carload lots or fraction thereof of the same figured or ordered weight per linear foot.

ROLLING AND CUTTING TOLERANCES

ANGLES, BULB ANGLES AND ZEES (STRUCTURAL SIZES)



Scale of Permissible Tolerances exaggerated for clarity.

ROLLING TOLERANCES

Size-Length of Leg	Thick-ness	Depth of Section d		Length of Leg b		Out of Square	Weight	
		+	—	+	—	c	+	—
3″ to 4″ incl.	All	⅛″	$\frac{1}{16}$″	⅛″	$\frac{3}{32}$″	1½°, or 3/128″ per inch of leg length	2½%	2½%
Over 4″ to 6″ incl.	All	⅛″	$\frac{1}{16}$″	⅛″	⅛″		2½%	2½%
Over 6″	All	⅛″	$\frac{1}{16}$″	$\frac{3}{16}$″	⅛″		2½%	2½%

CUTTING TOLERANCES

Section	Thick-ness	Up to 30′ incl.		Over 30′ to 40′ incl.		Over 40′	
		Over	Under	Over	Under	Over	Under
Structural	All	¾″	0	1″	0	1¼″	0

Ends out of square—For Angles and Bulb Angles 1½ degrees, or $\frac{3}{128}$″ per inch of leg length.

For Zees 1½ degrees, or $\frac{3}{128}$″ per inch of sum of leg lengths.

Camber tolerance: $\frac{1}{8}'' \times \frac{\text{total length in feet}}{5'}$

Weight tolerances are based on each shipment consisting of carload lots or fraction thereof of the same figured or ordered weight per linear foot.

Longer leg of unequal leg angle determines size for tolerances.

PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS OF ROLLED STEEL STRUCTURAL SHAPES AND PLATES

AMERICAN SOCIETY FOR TESTING MATERIALS: A 7-46

Permissible Variations

(a) One cubic inch of rolled steel is assumed to weigh 0.2833 lb. The cross-sectional area or weight of each structural-size shape shall not vary more than 2.5 per cent. from the theoretical or specified amounts. The thickness or weights of rectangular sheared mill plates and of universal mill plates shall conform to the requirements of Paragraphs (b), (c) and (d).

(b) Plates, when ordered to thickness. No plate shall vary more than 0.01 in. under the thickness specified.

The overweight in each lot[1] of plates in each shipment shall not exceed the amount given in Table I.

(c) Plates, when ordered to weight per square foot. The weight of each lot[1] of plates in each shipment shall not vary from the weight ordered more than the amounts given in Table II.

(d) Plates over 2 in. in thickness. Each plate over 2 in. in thickness shall conform to the permissible variations over ordered thickness given in Table III.

TABLE I. PERMISSIBLE OVERWEIGHTS OF PLATES TWO INCHES AND UNDER IN THICKNESS WHEN ORDERED TO THICKNESS

Specified Thickness, Inches	Permissible Excess in Average Weight of Lots[1] for Widths Given, in Inches, Expressed in Percentage of Nominal Weights										
	48 and under	Over 48 to 60, excl.	60 to 72, excl.	72 to 84, excl.	84 to 96, excl.	96 to 108, excl.	108 to 120, excl.	120 to 132, excl.	132 to 144, excl.	144 to 168, excl.	168 and over
3/16 to 1/4, excl.		8	9	10	12	14	16	18			
1/4 to 5/16, "	6	7	8	9	10	12	14	16	19		
5/16 to 3/8, "	5	6	7	8	9	10	12	14	17	18	
3/8 to 7/16, "	4.5	5	6	7	8	9	10	12	15	16	18
7/16 to 1/2, "	4	4.5	5	6	7	8	9	10	13	14	16
1/2 to 5/8, "	4	4	4.5	5	6	7	8	9	11	12	14
5/8 to 3/4, "	4	4	4	4.5	5	6	7	8	9	10	12
3/4 to 1, "	3.5	4	4	4	4.5	5	6	7	8	9	11
1 to 2, incl.	3.5	3.5	4	4	4	4.5	5	6	7	8	9

Permissible variations in weight for individual plates shall be one and one-third times the amounts prescribed in this table.

Permissible variation under specified thickness, 0.01 in.

[1]The term "lot" as applied to Table I means all the plates of each group width and group thickness represented in each shipment.

PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS OF ROLLED STEEL STRUCTURAL SHAPES AND PLATES

AMERICAN SOCIETY FOR TESTING MATERIALS: A 7-46

TABLE II. PERMISSIBLE VARIATIONS OF PLATES ORDERED TO WEIGHT

Specified Weight, lb. per sq. ft.	Permissible Variations in Average Weight of Lots[1] for Widths Given, in Inches, Expressed in Percentage of Ordered Weight per Square Foot.																					
	48 or under		Over 48 to 60, excl.		60 to 72, excl.		72 to 84, excl.		84 to 96, excl.		96 to 108, excl.		108 to 120, excl.		120 to 132, excl.		132 to 144, excl.		144 to 168, excl.		168 or over	
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under
7.65 to 10, excl.	----	----	4.5	3	5	3	5.5	3	6	3	----	----	----	----	----	----	----	----	----	----	----	----
10 to 12.5, excl.	4	3	4.5	3	5	3	5.5	3	6	3	6.5	3	7	3	8	3	9	3	----	----	----	----
12.5 to 15, excl.	4	3	4	3	4.5	3	5	3	5.5	3	5.5	3	6	3	7.5	3	8	3	----	----	----	----
15 to 17.5, excl.	3.5	3	3.5	3	4	3	4.5	3	5	3	5	3	5.5	3	6	3	7	3	9	3	10	3
17.5 to 20, excl.	3.5	2.5	3.5	2.5	3.5	3	4	3	4.5	3	4.5	3	5	3	5.5	3	6	3	8	3	9	3
20 to 25, excl.	3.5	2.5	3.5	2.5	3.5	3	3.5	3	4	3	4	3	4.5	3	5	3	5.5	3	7	3	8	3
25 to 30, excl.	3	2.5	3.5	2.5	3.5	2.5	3.5	3	3.5	3	3.5	2.5	4	3	4.5	3	5	3	6.5	3	7	3
30 to 40, excl.	3	2	3	2	3	2	3	2	3.5	2	3.5	2	3.5	2.5	4	3	4.5	3	6	3	6.5	3
40 to 81.6, incl.	2.5	2	3	2	3	2	3	2	3.5	2	3.5	2	3	2.5	3.5	3	4	3	5.5	3	6	3

Permissible variations in weight for individual plates shall be one and one-third times the amounts prescribed in this table.

[1]The term "lot" as applied to Table II, means all the plates of each group width and group weight represented in each shipment.

TABLE III. PERMISSIBLE VARIATIONS OVER ORDERED THICKNESS OF PLATES OVER TWO INCHES THICK

Specified Thickness, Inches	Variations over Specified Thickness for Width Given					
	Under 36	36 to 60, excl.	60 to 84, excl.	84 to 120, excl.	120 to 132, excl.	132 and over
Over 2 to 3, excl.	1/16	3/32	7/64	1/8	1/8	9/64
3 to 4, "	5/64	3/32	7/64	1/8	1/8	9/64
4 to 6, "	3/32	1/8	9/64	9/64	5/32	11/64
6 to 8, "	7/64	1/8	5/32	5/32	11/64	
8 to 10, "		11/64	3/16	3/16		
10 to 12, "		3/16	15/64	15/64		
12 to 15, incl.		7/32	1/4			

Each plate shall not vary more than 0.01 in. under the ordered thickness.

PERMISSIBLE VARIATIONS IN LENGTH, WIDTH, FLATNESS AND CAMBER FOR PLATES OVER TWO INCHES THICK

AMERICAN IRON AND STEEL INSTITUTE, 1943

PERMISSIBLE VARIATIONS IN LENGTH AND WIDTH FOR GAS CUT PLATES

Ordered Thickness, Inches	All Lengths and Widths — Variation Over
Over 2 to 3, excl.	5/8 in.
3 to 4, excl.	5/8 in.
4 to 6, excl.	3/4 in.
6 to 8, excl.	7/8 in.
8 to 15, incl.	1 in.

These variations may be taken all under, or divided over and under, if so specified when ordering.

Plates with rolled edges will be gas cut to length only.

PERMISSIBLE VARIATIONS IN WIDTH FOR ROLLED EDGE (UNIVERSAL MILL) PLATES

Ordered Dimensions, Inches		Width Variation	
Width	Thickness	Over, In.	Under, In.
60 or under	Over 2 to 10, incl.	3/8	1/8
30 or under	Over 10 to 15, incl.	1/2	1/8
Over 30 to 60, inclusive	Over 10 to 15, incl.	5/8	1/8

PERMISSIBLE VARIATIONS FROM TRUE FLATNESS FOR UNIVERSAL MILL AND SHEARED MILL PLATES

Ordered Thickness, Inches	For Length or Width, Inches								
	Under 36	36 to 48, excl.	48 to 60, excl.	60 to 72, excl.	72 to 84, excl.	84 to 96, excl.	96 to 108, excl.	108 to 120, excl.	120 to 144, incl.
Over 2 to 4, excl.	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4
4 to 6, excl.	1/4	5/16	3/8	1/2	9/16	5/8	3/4	7/8	1
6 to 8, excl.	5/16	7/16	1/2	5/8	3/4	7/8	15/16	1	1
8 to 10, excl.	3/8	1/2	5/8	3/4	7/8	1	1	1	1
10 to 12, excl.	1/2	11/16	7/8	1	1	1	1	1	1
12 to 15, incl.	5/8	13/16	7/8	1	1	1	1	1	1

PERMISSIBLE CAMBER FOR UNIVERSAL MILL PLATES

Ordered Dimensions, Inches		Camber
Width	Thickness	
30 or under	Over 2 to 15, incl.	$\frac{3}{16}$ in. x $\frac{\text{Total Length (feet)}}{5'}$
30 to 60, incl.	Over 2 to 15, incl.	$\frac{1}{4}$ in. x $\frac{\text{Total Length (feet)}}{5'}$

MISCELLANEOUS DATA FOR ESTIMATING AND DESIGNING

WEIGHT AND AREA OF BARS AND PLATES

ECONOMY OF SHAPES USED AS BEAMS

TABLES FOR DESIGN OF PLATE GIRDERS

NET SECTION OF RIVETED TENSION MEMBERS

DIMENSIONS, WEIGHTS AND PROPERTIES OF PLATE AND ANGLE GIRDER SECTIONS

DIMENSIONS, WEIGHTS AND PROPERTIES OF COMPOUND COLUMN SECTIONS

WEIGHTS AND PROPERTIES OF SHAPE COMBINATIONS

WEIGHTS AND PROPERTIES OF TWO ANGLES

BEARING PLATE AND BASE PLATE DESIGN

CRANE RAILS AND FASTENINGS

THREADED STRUCTURAL ACCESSORIES

EYE BARS

PIPE

SHEET METAL CONSTRUCTION

BATTLEDECK FLOOR

SQUARE AND ROUND BARS
WEIGHT AND AREA

Size Inches	Weight Lb. per Foot		Area Square Inches		Size Inches	Weight Lb. per Foot		Area Square Inches	
	■	●	▨	◍		■	●	▨	◍
0					3	30.60	24.03	9.000	7.069
1/16	.013	.010	.0039	.0031	1/16	31.89	25.05	9.379	7.366
1/8	.053	.042	.0156	.0123	1/8	33.20	26.08	9.766	7.670
3/16	.120	.094	.0352	.0276	3/16	34.54	27.13	10.160	7.980
1/4	.213	.167	.0625	.0491	1/4	35.91	28.21	10.563	8.296
5/16	.332	.261	.0977	.0767	5/16	37.31	29.30	10.973	8.618
3/8	.478	.376	.1406	.1105	3/8	38.73	30.42	11.391	8.946
7/16	.651	.511	.1914	.1503	7/16	40.18	31.55	11.816	9.281
1/2	.850	.668	.2500	.1963	1/2	41.65	32.71	12.250	9.621
9/16	1.076	.845	.3164	.2485	9/16	43.15	33.89	12.691	9.968
5/8	1.328	1.043	.3906	.3068	5/8	44.68	35.09	13.141	10.321
11/16	1.607	1.262	.4727	.3712	11/16	46.23	36.31	13.598	10.680
3/4	1.913	1.502	.5625	.4418	3/4	47.81	37.55	14.063	11.045
13/16	2.245	1.763	.6602	.5185	13/16	49.42	38.81	14.535	11.416
7/8	2.603	2.044	.7656	.6013	7/8	51.05	40.10	15.016	11.793
15/16	2.988	2.347	.8789	.6903	15/16	52.71	41.40	15.504	12.177
1	3.400	2.670	1.0000	.7854	4	54.40	42.73	16.000	12.566
1/16	3.838	3.015	1.1289	.8866	1/16	56.11	44.07	16.504	12.962
1/8	4.303	3.380	1.2656	.9940	1/8	57.85	45.44	17.016	13.364
3/16	4.795	3.766	1.4102	1.1075	3/16	59.62	46.83	17.535	13.772
1/4	5.313	4.172	1.5625	1.2272	1/4	61.41	48.23	18.063	14.186
5/16	5.857	4.600	1.7227	1.3530	5/16	63.23	49.66	18.598	14.607
3/8	6.428	5.049	1.8906	1.4849	3/8	65.08	51.11	19.141	15.033
7/16	7.026	5.518	2.0664	1.6230	7/16	66.95	52.58	19.691	15.466
1/2	7.650	6.008	2.2500	1.7671	1/2	68.85	54.07	20.250	15.904
9/16	8.301	6.519	2.4414	1.9175	9/16	70.78	55.59	20.816	16.349
5/8	8.978	7.051	2.6406	2.0739	5/8	72.73	57.12	21.391	16.800
11/16	9.682	7.604	2.8477	2.2365	11/16	74.71	58.67	21.973	17.257
3/4	10.413	8.178	3.0625	2.4053	3/4	76.71	60.25	22.563	17.721
13/16	11.170	8.773	3.2852	2.5802	13/16	78.74	61.85	23.160	18.190
7/8	11.953	9.388	3.5156	2.7612	7/8	80.80	63.46	23.766	18.665
15/16	12.763	10.024	3.7539	2.9483	15/16	82.89	65.10	24.379	19.147
2	13.600	10.681	4.0000	3.1416	5	85.00	66.76	25.000	19.635
1/16	14.463	11.359	4.2539	3.3410	1/16	87.14	68.44	25.629	20.129
1/8	15.353	12.058	4.5156	3.5466	1/8	89.30	70.14	26.266	20.629
3/16	16.270	12.778	4.7852	3.7583	3/16	91.49	71.86	26.910	21.135
1/4	17.213	13.519	5.0625	3.9761	1/4	93.71	73.60	27.563	21.648
5/16	18.182	14.280	5.3477	4.2000	5/16	95.96	75.36	28.223	22.166
3/8	19.178	15.062	5.6406	4.4301	3/8	98.23	77.15	28.891	22.691
7/16	20.201	15.866	5.9414	4.6664	7/16	100.53	78.95	29.566	23.221
1/2	21.250	16.690	6.2500	4.9087	1/2	102.85	80.78	30.250	23.758
9/16	22.326	17.534	6.5664	5.1572	9/16	105.20	82.62	30.941	24.301
5/8	23.428	18.400	6.8906	5.4119	5/8	107.58	84.49	31.641	24.850
11/16	24.557	19.287	7.2227	5.6727	11/16	109.98	86.38	32.348	25.406
3/4	25.713	20.195	7.5625	5.9396	3/4	112.41	88.29	33.063	25.967
13/16	26.895	21.123	7.9102	6.2126	13/16	114.87	90.22	33.785	26.535
7/8	28.103	22.072	8.2656	6.4918	7/8	117.35	92.17	34.516	27.109
15/16	29.338	23.042	8.6289	6.7771	15/16	119.86	94.14	35.254	27.688
3	30.600	24.033	9.0000	7.0686	6	122.40	96.13	36.000	28.274

SQUARE AND ROUND BARS

WEIGHT AND AREA

Size Inches	Weight Lb. per Foot		Area Square Inches		Size Inches	Weight Lb. per Foot		Area Square Inches	
	■	●	▨	◍		■	●	▨	◍
6	122.40	96.13	36.000	28.274	9	275.40	216.30	81.000	63.617
1/16	124.96	98.15	36.754	28.866	1/16	279.24	219.31	82.129	64.504
1/8	127.55	100.18	37.516	29.465	1/8	283.10	222.35	83.266	65.397
3/16	130.17	102.23	38.285	30.069	3/16	286.99	225.41	84.410	66.296
1/4	132.81	104.31	39.063	30.680	1/4	290.91	228.48	85.563	67.201
5/16	135.48	106.41	39.848	31.296	5/16	294.86	231.58	86.723	68.112
3/8	138.18	108.53	40.641	31.919	3/8	298.83	234.70	87.891	69.029
7/16	140.90	110.66	41.441	32.548	7/16	302.83	237.84	89.066	69.953
1/2	143.65	112.82	42.250	33.183	1/2	306.85	241.00	90.250	70.882
9/16	146.43	115.00	43.066	33.824	9/16	310.90	244.18	91.441	71.818
5/8	149.23	117.20	43.891	34.472	5/8	314.98	247.38	92.641	72.760
11/16	152.06	119.43	44.723	35.125	11/16	319.08	250.61	93.848	73.708
3/4	154.91	121.67	45.563	35.785	3/4	323.21	253.85	95.063	74.662
13/16	157.79	123.93	46.410	36.450	13/16	327.37	257.12	96.285	75.622
7/8	160.70	126.22	47.266	37.122	7/8	331.55	260.40	97.516	76.589
15/16	163.64	128.52	48.129	37.800	15/16	335.76	263.71	98.754	77.561
7	166.60	130.85	49.000	38.485	10	340.00	267.04	100.000	78.540
1/16	169.59	133.19	49.879	39.175	1/16	344.26	270.38	101.254	79.525
1/8	172.60	135.56	50.766	39.871	1/8	348.55	273.75	102.516	80.516
3/16	175.64	137.95	51.660	40.574	3/16	352.87	277.14	103.785	81.513
1/4	178.71	140.36	52.563	41.282	1/4	357.21	280.55	105.063	82.516
5/16	181.81	142.79	53.473	41.997	5/16	361.58	283.99	106.348	83.525
3/8	184.93	145.24	54.391	42.718	3/8	365.98	287.44	107.641	84.541
7/16	188.07	147.71	55.316	43.445	7/16	370.40	290.91	108.941	85.563
1/2	191.25	150.21	56.250	44.179	1/2	374.85	294.41	110.250	86.590
9/16	194.45	152.72	57.191	44.918	9/16	379.33	297.92	111.566	87.624
5/8	197.68	155.26	58.141	45.664	5/8	383.83	301.46	112.891	88.664
11/16	200.93	157.81	59.098	46.415	11/16	388.36	305.02	114.223	89.710
3/4	204.21	160.39	60.063	47.173	3/4	392.91	308.59	115.563	90.763
13/16	207.52	162.99	61.035	47.937	13/16	397.49	312.19	116.910	91.821
7/8	210.85	165.60	62.016	48.707	7/8	402.10	315.81	118.266	92.886
15/16	214.21	168.24	63.004	49.483	15/16	406.74	319.45	119.629	93.957
8	217.60	170.90	64.000	50.265	11	411.40	323.11	121.000	95.033
1/16	221.01	173.58	65.004	51.054	1/16	416.09	326.80	122.379	96.116
1/8	224.45	176.29	66.016	51.849	1/8	420.80	330.50	123.766	97.205
3/16	227.92	179.01	67.035	52.649	3/16	425.54	334.22	125.160	98.301
1/4	231.41	181.75	68.063	53.456	1/4	430.31	337.97	126.563	99.402
5/16	234.93	184.52	69.098	54.269	5/16	435.11	341.73	127.973	100.510
3/8	238.48	187.30	70.141	55.088	3/8	439.93	345.52	129.391	101.623
7/16	242.05	190.11	71.191	55.914	7/16	444.78	349.33	130.816	102.743
1/2	245.65	192.93	72.250	56.745	1/2	449.65	353.16	132.250	103.869
9/16	249.28	195.78	73.316	57.583	9/16	454.55	357.00	133.691	105.001
5/8	252.93	198.65	74.391	58.426	5/8	459.48	360.87	135.141	106.139
11/16	256.61	201.54	75.473	59.276	11/16	464.43	364.76	136.598	107.284
3/4	260.31	204.45	76.563	60.132	3/4	469.41	368.68	138.063	108.434
13/16	264.04	207.38	77.660	60.994	13/16	474.42	372.61	139.535	109.591
7/8	267.80	210.33	78.766	61.863	7/8	479.45	376.56	141.016	110.754
15/16	271.59	213.31	79.879	62.737	15/16	484.51	380.54	142.504	111.923
9	275.40	216.30	81.000	63.617	12	489.60	384.53	144.000	113.098

WEIGHT OF RECTANGULAR SECTIONS

POUNDS PER LINEAR FOOT

Width In.	Thickness, Inches													
	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
1/4	.16	.21	.27	.32	.37	.43	.48	.53	.58	.64	.69	.74	.80	.85
1/2	.32	.43	.53	.64	.74	.85	.96	1.06	1.17	1.28	1.38	1.49	1.59	1.70
3/4	.48	.64	.80	.96	1.12	1.28	1.43	1.59	1.75	1.91	2.07	2.23	2.39	2.55
1	.64	.85	1.06	1.28	1.49	1.70	1.91	2.13	2.34	2.55	2.76	2.98	3.19	3.40
1 1/4	.80	1.06	1.33	1.59	1.86	2.13	2.39	2.66	2.92	3.19	3.45	3.72	3.98	4.25
1 1/2	.96	1.28	1.59	1.91	2.23	2.55	2.87	3.19	3.51	3.83	4.14	4.46	4.78	5.10
1 3/4	1.12	1.49	1.86	2.23	2.60	2.98	3.35	3.72	4.09	4.46	4.83	5.21	5.58	5.95
2	1.28	1.70	2.13	2.55	2.98	3.40	3.83	4.25	4.68	5.10	5.53	5.95	6.38	6.80
2 1/4	1.43	1.91	2.39	2.87	3.35	3.83	4.30	4.78	5.26	5.74	6.22	6.69	7.17	7.65
2 1/2	1.59	2.13	2.66	3.19	3.72	4.25	4.78	5.31	5.84	6.38	6.91	7.44	7.97	8.50
2 3/4	1.75	2.34	2.92	3.51	4.09	4.68	5.26	5.84	6.43	7.01	7.60	8.18	8.77	9.35
3	1.91	2.55	3.19	3.83	4.46	5.10	5.74	6.38	7.01	7.65	8.29	8.93	9.56	10.2
3 1/4	2.07	2.76	3.45	4.14	4.83	5.53	6.22	6.91	7.60	8.29	8.98	9.67	10.4	11.1
3 1/2	2.23	2.98	3.72	4.46	5.21	5.95	6.69	7.44	8.18	8.93	9.67	10.4	11.2	11.9
3 3/4	2.39	3.19	3.98	4.78	5.58	6.38	7.17	7.97	8.77	9.56	10.4	11.2	12.0	12.8
4	2.55	3.40	4.25	5.10	5.95	6.80	7.65	8.50	9.35	10.2	11.1	11.9	12.8	13.6
4 1/4	2.71	3.61	4.52	5.42	6.32	7.23	8.13	9.03	9.93	10.8	11.7	12.6	13.6	14.5
4 1/2	2.87	3.83	4.78	5.74	6.69	7.65	8.61	9.56	10.5	11.5	12.4	13.4	14.3	15.3
4 3/4	3.03	4.04	5.05	6.06	7.07	8.08	9.08	10.1	11.1	12.1	13.1	14.1	15.1	16.2
5	3.19	4.25	5.31	6.38	7.44	8.50	9.56	10.6	11.7	12.8	13.8	14.9	15.9	17.0
5 1/4	3.35	4.46	5.58	6.69	7.81	8.93	10.0	11.2	12.3	13.4	14.5	15.6	16.7	17.9
5 1/2	3.51	4.68	5.84	7.01	8.18	9.35	10.5	11.7	12.9	14.0	15.2	16.4	17.5	18.7
5 3/4	3.67	4.89	6.11	7.33	8.55	9.78	11.0	12.2	13.4	14.7	15.9	17.1	18.3	19.6
6	3.83	5.10	6.38	7.65	8.93	10.2	11.5	12.8	14.0	15.3	16.6	17.9	19.1	20.4
6 1/4	3.98	5.31	6.64	7.97	9.30	10.6	12.0	13.3	14.6	15.9	17.3	18.6	19.9	21.3
6 1/2	4.14	5.53	6.91	8.29	9.67	11.1	12.4	13.8	15.2	16.6	18.0	19.3	20.7	22.1
6 3/4	4.30	5.74	7.17	8.61	10.0	11.5	12.9	14.3	15.8	17.2	18.7	20.1	21.5	23.0
7	4.46	5.95	7.44	8.93	10.4	11.9	13.4	14.9	16.4	17.9	19.3	20.8	22.3	23.8
7 1/4	4.62	6.16	7.70	9.24	10.8	12.3	13.9	15.4	17.0	18.5	20.0	21.6	23.1	24.7
7 1/2	4.78	6.38	7.97	9.56	11.2	12.8	14.3	15.9	17.5	19.1	20.7	22.3	23.9	25.5
7 3/4	4.94	6.59	8.23	9.88	11.5	13.2	14.8	16.5	18.1	19.8	21.4	23.1	24.7	26.4
8	5.10	6.80	8.50	10.2	11.9	13.6	15.3	17.0	18.7	20.4	22.1	23.8	25.5	27.2
8 1/4	5.26	7.01	8.77	10.5	12.3	14.0	15.8	17.5	19.3	21.0	22.8	24.5	26.3	28.1
8 1/2	5.42	7.23	9.03	10.8	12.6	14.5	16.3	18.1	19.9	21.7	23.5	25.3	27.1	28.9
8 3/4	5.58	7.44	9.30	11.2	13.0	14.9	16.7	18.6	20.5	22.3	24.2	26.0	27.9	29.8
9	5.74	7.65	9.56	11.5	13.4	15.3	17.2	19.1	21.0	23.0	24.9	26.8	28.7	30.6
9 1/4	5.90	7.86	9.83	11.8	13.8	15.7	17.7	19.7	21.6	23.6	25.6	27.5	29.5	31.5
9 1/2	6.06	8.08	10.1	12.1	14.1	16.2	18.2	20.2	22.2	24.2	26.2	28.3	30.3	32.3
9 3/4	6.22	8.29	10.4	12.4	14.5	16.6	18.7	20.7	22.8	24.9	26.9	29.0	31.1	33.2
10	6.38	8.50	10.6	12.8	14.9	17.0	19.1	21.3	23.4	25.5	27.6	29.8	31.9	34.0

WEIGHT OF RECTANGULAR SECTIONS
POUNDS PER LINEAR FOOT

Width In.	Thickness, Inches													
	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
10¼	6.53	8.71	10.9	13.1	15.3	17.4	19.6	21.8	24.0	26.1	28.3	30.5	32.7	34.9
10½	6.69	8.93	11.2	13.4	15.6	17.9	20.1	22.3	24.5	26.8	29.0	31.2	33.5	35.7
10¾	6.85	9.14	11.4	13.7	16.0	18.3	20.6	22.8	25.1	27.4	29.7	32.0	34.3	36.6
11	7.01	9.35	11.7	14.0	16.4	18.7	21.0	23.4	25.7	28.1	30.4	32.7	35.1	37.4
11¼	7.17	9.56	12.0	14.3	16.7	19.1	21.5	23.9	26.3	28.7	31.1	33.5	35.9	38.3
11½	7.33	9.78	12.2	14.7	17.1	19.6	22.0	24.4	26.9	29.3	31.8	34.2	36.7	39.1
11¾	7.49	9.99	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5	40.0
12	7.65	10.2	12.8	15.3	17.9	20.4	23.0	25.5	28.1	30.6	33.2	35.7	38.3	40.8
12½	7.97	10.6	13.3	15.9	18.6	21.3	23.9	26.6	29.2	31.9	34.5	37.2	39.8	42.5
13	8.29	11.1	13.8	16.6	19.3	22.1	24.9	27.6	30.4	33.2	35.9	38.7	41.4	44.2
13½	8.61	11.5	14.3	17.2	20.1	23.0	25.8	28.7	31.6	34.4	37.3	40.2	43.0	45.9
14	8.93	11.9	14.9	17.9	20.8	23.8	26.8	29.8	32.7	35.7	38.7	41.7	44.6	47.6
14½	9.24	12.3	15.4	18.5	21.6	24.7	27.7	30.8	33.9	37.0	40.1	43.1	46.2	49.3
15	9.56	12.8	15.9	19.1	22.3	25.5	28.7	31.9	35.1	38.3	41.4	44.6	47.8	51.0
15½	9.88	13.2	16.5	19.8	23.1	26.4	29.6	32.9	36.2	39.5	42.8	46.1	49.4	52.7
16	10.2	13.6	17.0	20.4	23.8	27.2	30.6	34.0	37.4	40.8	44.2	47.6	51.0	54.4
16½	10.5	14.0	17.5	21.0	24.5	28.1	31.6	35.1	38.6	42.1	45.6	49.1	52.6	56.1
17	10.8	14.5	18.1	21.7	25.3	28.9	32.5	36.1	39.7	43.4	47.0	50.6	54.2	57.8
17½	11.2	14.9	18.6	22.3	26.0	29.8	33.5	37.2	40.9	44.6	48.3	52.1	55.8	59.5
18	11.5	15.3	19.1	23.0	26.8	30.6	34.4	38.3	42.1	45.9	49.7	53.6	57.4	61.2
18½	11.8	15.7	19.7	23.6	27.5	31.5	35.4	39.3	43.2	47.2	51.1	55.0	59.0	62.9
19	12.1	16.2	20.2	24.2	28.3	32.3	36.3	40.4	44.4	48.5	52.5	56.5	60.6	64.6
19½	12.4	16.6	20.7	24.9	29.0	33.2	37.3	41.4	45.6	49.7	53.9	58.0	62.2	66.3
20	12.8	17.0	21.3	25.5	29.8	34.0	38.3	42.5	46.8	51.0	55.3	59.5	63.8	68.0
20½	13.1	17.4	21.8	26.1	30.5	34.9	39.2	43.6	47.9	52.3	56.6	61.0	65.3	69.7
21	13.4	17.9	22.3	26.8	31.2	35.7	40.2	44.6	49.1	53.6	58.0	62.5	66.9	71.4
21½	13.7	18.3	22.8	27.4	32.0	36.6	41.1	45.7	50.3	54.8	59.4	64.0	68.5	73.1
22	14.0	18.7	23.4	28.1	32.7	37.4	42.1	46.8	51.4	56.1	60.8	65.5	70.1	74.8
22½	14.3	19.1	23.9	28.7	33.5	38.3	43.0	47.8	52.6	57.4	62.2	66.9	71.7	76.5
23	14.7	19.6	24.4	29.3	34.2	39.1	44.0	48.9	53.8	58.7	63.5	68.4	73.3	78.2
23½	15.0	20.0	25.0	30.0	35.0	40.0	44.9	49.9	54.9	59.9	64.9	69.9	74.9	79.9
24	15.3	20.4	25.5	30.6	35.7	40.8	45.9	51.0	56.1	61.2	66.3	71.4	76.5	81.6
25	15.9	21.3	26.6	31.9	37.2	42.5	47.8	53.1	58.4	63.8	69.1	74.4	79.7	85.0
26	16.6	22.1	27.6	33.2	38.7	44.2	49.7	55.3	60.8	66.3	71.8	77.4	82.9	88.4
27	17.2	23.0	28.7	34.4	40.2	45.9	51.6	57.4	63.1	68.9	74.6	80.3	86.1	91.8
28	17.9	23.8	29.8	35.7	41.7	47.6	53.6	59.5	65.5	71.4	77.4	83.3	89.3	95.2
29	18.5	24.7	30.8	37.0	43.1	49.3	55.5	61.6	67.8	74.0	80.1	86.3	92.4	98.6
30	19.1	25.5	31.9	38.3	44.6	51.0	57.4	63.8	70.1	76.5	82.9	89.3	95.6	102
31	19.8	26.4	32.9	39.5	46.1	52.7	59.3	65.9	72.5	79.1	85.6	92.2	98.8	105
32	20.4	27.2	34.0	40.8	47.6	54.4	61.2	68.0	74.8	81.6	88.4	95.2	102	109

WEIGHT OF RECTANGULAR SECTIONS

POUNDS PER LINEAR FOOT

Width In.	Thickness, Inches													
	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
33	21.0	28.1	35.1	42.1	49.1	56.1	63.1	70.1	77.1	84.2	91.2	98.2	105	112
34	21.7	28.9	36.1	43.4	50.6	57.8	65.0	72.3	79.5	86.7	93.9	101	108	116
35	22.3	29.8	37.2	44.6	52.1	59.5	66.9	74.4	81.8	89.3	96.1	104	112	119
36	23.0	30.6	38.3	45.9	53.6	61.2	68.9	76.5	84.2	91.8	99.5	107	115	122
37	23.6	31.5	39.3	47.2	55.0	62.9	70.8	78.6	86.5	94.4	102	110	118	126
38	24.2	32.3	40.4	48.5	56.5	64.6	72.7	80.8	88.8	96.9	105	113	121	129
39	24.9	33.2	41.4	49.7	58.0	66.3	74.6	82.9	91.2	99.5	108	116	124	133
40	25.5	34.0	42.5	51.0	59.5	68.0	76.5	85.0	93.5	102	111	119	128	136
41	26.1	34.9	43.6	52.3	61.0	69.7	78.4	87.1	95.8	105	113	122	131	139
42	26.8	35.7	44.6	53.6	62.5	71.4	80.3	89.3	98.2	107	116	125	134	143
43	27.4	36.6	45.7	54.8	64.0	73.1	82.2	91.4	101	110	119	128	137	146
44	28.1	37.4	46.8	56.1	65.5	74.8	84.2	93.5	103	112	122	131	140	150
45	28.7	38.3	47.8	57.4	66.9	76.5	86.1	95.6	105	115	124	134	143	153
46	29.3	39.1	48.9	58.7	68.4	78.2	88.0	97.8	108	117	127	137	147	156
47	30.0	40.0	49.9	59.9	69.9	79.9	89.9	99.9	110	120	130	140	150	160
48	30.6	40.8	51.0	61.2	71.4	81.6	91.8	102	112	122	133	143	153	163
49	31.2	41.7	52.1	62.5	72.9	83.3	93.7	104	115	125	135	146	156	167
50	31.9	42.5	53.1	63.8	74.4	85.0	95.6	106	117	128	138	149	159	170
51	32.5	43.4	54.2	65.0	75.9	86.7	97.5	108	119	130	141	152	163	173
52	33.2	44.2	55.3	66.3	77.4	88.4	99.5	111	122	133	144	155	166	177
53	33.8	45.1	56.3	67.6	78.8	90.1	101	113	124	135	146	158	169	180
54	34.4	45.9	57.4	68.9	80.3	91.8	103	115	126	138	149	161	172	184
55	35.1	46.8	58.4	70.1	81.8	93.5	105	117	129	140	152	164	175	187
56	35.7	47.6	59.5	71.4	83.3	95.2	107	119	131	143	155	167	179	190
57	36.3	48.5	60.6	72.7	84.8	96.9	109	121	133	145	158	170	182	194
58	37.0	49.3	61.6	74.0	86.3	98.6	111	123	136	148	160	173	185	197
59	37.6	50.2	62.7	75.2	87.8	100	113	125	138	151	163	176	188	201
60	38.3	51.0	63.8	76.5	89.3	102	115	128	140	153	166	179	191	204
61	38.9	51.9	64.8	77.8	90.7	104	117	130	143	156	169	182	194	207
62	39.5	52.7	65.9	79.1	92.2	105	119	132	145	158	171	185	198	211
63	40.2	53.6	66.9	80.3	93.7	107	121	134	147	161	174	187	201	214
64	40.8	54.4	68.0	81.6	95.2	109	122	136	150	163	177	190	204	218
65	41.4	55.3	69.1	82.9	96.7	111	124	138	152	166	180	193	207	221
66	42.1	56.1	70.1	84.2	98.2	112	126	140	154	168	182	196	210	224
67	42.7	57.0	71.2	85.4	99.7	114	128	142	157	171	185	199	214	228
68	43.4	57.8	72.3	86.7	101	116	130	145	159	173	188	202	217	231
69	44.0	58.7	73.3	88.0	103	117	132	147	161	176	191	205	220	235
70	44.6	59.5	74.4	89.3	104	119	134	149	164	179	193	208	223	238
71	45.3	60.4	75.4	90.5	106	121	136	151	166	181	196	211	226	241
72	45.9	61.2	76.5	91.8	107	122	138	153	168	184	199	214	230	245

WEIGHT OF RECTANGULAR SECTIONS
POUNDS PER LINEAR FOOT

Width In.	Thickness, Inches													
	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
73	46.5	62.1	77.6	93.1	109	124	140	155	171	186	202	217	233	248
74	47.2	62.9	78.6	94.4	110	126	142	157	173	189	204	220	236	252
75	47.8	63.8	79.7	95.6	112	128	143	159	175	191	207	223	239	255
76	48.5	64.6	80.8	96.9	113	129	145	162	178	194	210	226	242	258
77	49.1	65.5	81.8	98.2	115	131	147	164	180	196	213	229	245	262
78	49.7	66.3	82.9	99.5	116	133	149	166	182	199	216	232	249	265
79	50.4	67.2	83.9	101	118	134	151	168	185	202	218	235	252	269
80	51.0	68.0	85.0	102	119	136	153	170	187	204	221	238	255	272
81	51.6	68.9	86.1	103	121	138	155	172	189	207	224	241	258	275
82	52.3	69.7	87.1	105	122	139	157	174	192	209	227	244	261	279
83	52.9	70.6	88.2	106	124	141	159	176	194	212	229	247	265	282
84	53.6	71.4	89.3	107	125	143	161	179	196	214	232	250	268	286
85	54.2	72.3	90.3	108	126	145	163	181	199	217	235	253	271	289
86	54.8	73.1	91.4	110	128	146	165	183	201	219	238	256	274	292
87	55.5	74.0	92.4	111	129	148	166	185	203	222	240	259	277	296
88	56.1	74.8	93.5	112	131	150	168	187	206	224	243	262	281	299
89	56.7	75.7	94.6	114	132	151	170	189	208	227	246	265	284	303
90	57.4	76.5	95.6	115	134	153	172	191	210	230	249	268	287	306
91	....	77.4	96.7	116	135	155	174	193	213	232	251	271	290	309
92	....	78.2	97.8	117	137	156	176	196	215	235	254	274	293	313
93	....	79.1	98.8	119	138	158	178	198	217	237	257	277	296	316
94	....	79.9	99.9	120	140	160	180	200	220	240	260	280	300	320
95	....	80.8	101	121	141	162	182	202	222	242	262	283	303	323
96	....	81.6	102	122	143	163	184	204	224	245	265	286	306	326
98	....	83.3	104	125	146	167	187	208	229	250	271	292	312	333
100	....	85.0	106	128	149	170	191	213	234	255	276	298	319	340
102	....	86.7	108	130	152	173	195	217	238	260	282	304	325	347
104	....	88.4	111	133	155	177	199	221	243	265	287	309	332	354
106	....	90.1	113	135	158	180	203	225	248	270	293	315	338	360
108	....	91.8	115	138	161	184	207	230	253	275	298	321	344	367
110	....	93.5	117	140	164	187	210	234	257	281	304	327	351	374
112	....	95.2	119	143	167	190	214	238	262	286	309	333	357	381
114	....	96.9	121	145	170	194	218	242	267	291	315	339	363	388
116	....	98.6	123	148	173	197	222	247	271	296	321	345	370	394
118	....	100	125	151	176	201	226	251	276	301	326	351	376	401
120	....	102	128	153	179	204	230	255	281	306	332	357	383	408
122	....	104	130	156	182	207	233	259	285	311	337	363	389	415
124	....	105	132	158	185	211	237	264	290	316	343	369	395	422
126	....	107	134	161	187	214	241	268	295	321	348	375	402	428
128	....	109	136	163	190	218	245	272	299	326	354	381	408	435

AREA OF RECTANGULAR SECTIONS

SQUARE INCHES

Width In.	Thickness, Inches 3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
1/4	.047	.063	.078	.094	.109	.125	.141	.156	.172	.188	.203	.219	.234	.250
1/2	.094	.125	.156	.188	.219	.250	.281	.313	.344	.375	.406	.438	.469	.500
3/4	.141	.188	.234	.281	.328	.375	.422	.469	.516	.563	.609	.656	.703	.750
1	.188	.250	.313	.375	.438	.500	.563	.625	.688	.750	.813	.875	.938	1.00
1 1/4	.234	.313	.391	.469	.547	.625	.703	.781	.859	.938	1.02	1.09	1.17	1.25
1 1/2	.281	.375	.469	.563	.656	.750	.844	.938	1.03	1.13	1.22	1.31	1.41	1.50
1 3/4	.328	.438	.547	.656	.766	.875	.984	1.09	1.20	1.31	1.42	1.53	1.64	1.75
2	.375	.500	.625	.750	.875	1.00	1.13	1.25	1.38	1.50	1.63	1.75	1.88	2.00
2 1/4	.422	.563	.703	.844	.984	1.13	1.27	1.41	1.55	1.69	1.83	1.97	2.11	2.25
2 1/2	.469	.625	.781	.938	1.09	1.25	1.41	1.56	1.72	1.88	2.03	2.19	2.34	2.50
2 3/4	.516	.688	.859	1.03	1.20	1.38	1.55	1.72	1.89	2.06	2.23	2.41	2.58	2.75
3	.563	.750	.938	1.13	1.31	1.50	1.69	1.88	2.06	2.25	2.44	2.63	2.81	3.00
3 1/4	.609	.813	1.02	1.22	1.42	1.63	1.83	2.03	2.23	2.44	2.64	2.84	3.05	3.25
3 1/2	.656	.875	1.09	1.31	1.53	1.75	1.97	2.19	2.41	2.63	2.84	3.06	3.28	3.50
3 3/4	.703	.938	1.17	1.41	1.64	1.88	2.11	2.34	2.58	2.81	3.05	3.28	3.52	3.75
4	.750	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
4 1/4	.797	1.06	1.33	1.59	1.86	2.13	2.39	2.66	2.92	3.19	3.45	3.72	3.98	4.25
4 1/2	.844	1.13	1.41	1.69	1.97	2.25	2.53	2.81	3.09	3.38	3.66	3.94	4.22	4.50
4 3/4	.891	1.19	1.48	1.78	2.09	2.38	2.67	2.97	3.27	3.56	3.86	4.16	4.45	4.75
5	.938	1.25	1.56	1.88	2.19	2.50	2.81	3.13	3.44	3.75	4.06	4.38	4.69	5.00
5 1/4	.984	1.31	1.64	1.97	2.30	2.63	2.95	3.28	3.61	3.94	4.27	4.59	4.92	5.25
5 1/2	1.03	1.38	1.72	2.06	2.41	2.75	3.09	3.44	3.78	4.13	4.47	4.81	5.16	5.50
5 3/4	1.08	1.44	1.80	2.16	2.52	2.88	3.23	3.59	3.95	4.31	4.67	5.03	5.39	5.75
6	1.13	1.50	1.88	2.25	2.63	3.00	3.38	3.75	4.13	4.50	4.88	5.25	5.63	6.00
6 1/4	1.17	1.56	1.95	2.34	2.73	3.13	3.52	3.91	4.30	4.69	5.08	5.47	5.86	6.25
6 1/2	1.22	1.63	2.03	2.44	2.84	3.25	3.66	4.06	4.47	4.88	5.28	5.69	6.09	6.50
6 3/4	1.27	1.69	2.10	2.53	2.95	3.38	3.80	4.22	4.64	5.06	5.48	5.91	6.33	6.75
7	1.31	1.75	2.19	2.63	3.06	3.50	3.94	4.38	4.81	5.25	5.69	6.13	6.56	7.00
7 1/4	1.36	1.81	2.27	2.72	3.17	3.63	4.08	4.53	4.98	5.44	5.89	6.34	6.80	7.25
7 1/2	1.41	1.88	2.34	2.81	3.28	3.75	4.22	4.69	5.16	5.63	6.09	6.56	7.03	7.50
7 3/4	1.45	1.94	2.42	2.91	3.39	3.88	4.36	4.84	5.33	5.81	6.30	6.78	7.27	7.75
8	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
8 1/4	1.55	2.06	2.58	3.09	3.61	4.13	4.64	5.16	5.67	6.19	6.70	7.22	7.73	8.25
8 1/2	1.59	2.13	2.66	3.19	3.72	4.25	4.78	5.31	5.84	6.38	6.91	7.44	7.97	8.50
8 3/4	1.64	2.19	2.73	3.28	3.83	4.38	4.92	5.47	6.02	6.56	7.11	7.66	8.20	8.75
9	1.69	2.25	2.81	3.38	3.94	4.50	5.06	5.63	6.19	6.75	7.31	7.88	8.44	9.00
9 1/4	1.73	2.31	2.89	3.47	4.05	4.63	5.20	5.78	6.36	6.94	7.52	8.09	8.67	9.25
9 1/2	1.78	2.38	2.97	3.56	4.16	4.75	5.34	5.94	6.53	7.13	7.72	8.31	8.91	9.50
9 3/4	1.83	2.44	3.05	3.66	4.27	4.88	5.48	6.09	6.70	7.31	7.92	8.53	9.14	9.75
10	1.88	2.50	3.13	3.75	4.38	5.00	5.63	6.25	6.88	7.50	8.13	8.75	9.38	10.00

AREA OF RECTANGULAR SECTIONS

SQUARE INCHES

Width In.	Thickness, Inches													
	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1
$10\frac{1}{4}$	1.92	2.56	3.20	3.84	4.48	5.13	5.77	6.41	7.05	7.69	8.33	8.97	9.61	10.25
$10\frac{1}{2}$	1.97	2.63	3.28	3.94	4.59	5.25	5.91	6.56	7.22	7.88	8.53	9.19	9.84	10.50
$10\frac{3}{4}$	2.02	2.69	3.36	4.03	4.70	5.38	6.05	6.72	7.39	8.06	8.73	9.41	10.08	10.75
11	2.06	2.75	3.44	4.13	4.81	5.50	6.19	6.88	7.56	8.25	8.94	9.63	10.31	11.00
$11\frac{1}{4}$	2.11	2.81	3.52	4.22	4.92	5.63	6.33	7.03	7.73	8.44	9.14	9.84	10.55	11.25
$11\frac{1}{2}$	2.16	2.88	3.59	4.31	5.03	5.75	6.47	7.19	7.91	8.63	9.34	10.06	10.78	11.50
$11\frac{3}{4}$	2.20	2.94	3.67	4.41	5.14	5.88	6.61	7.34	8.08	8.81	9.55	10.28	11.02	11.75
12	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00
$12\frac{1}{2}$	2.34	3.13	3.91	4.69	5.47	6.25	7.03	7.81	8.59	9.38	10.16	10.94	11.72	12.50
13	2.44	3.25	4.06	4.88	5.69	6.50	7.31	8.13	8.94	9.75	10.56	11.38	12.19	13.00
$13\frac{1}{2}$	2.53	3.38	4.22	5.06	5.91	6.75	7.59	8.44	9.28	10.13	10.97	11.81	12.66	13.50
14	2.63	3.50	4.38	5.25	6.13	7.00	7.88	8.75	9.63	10.50	11.38	12.25	13.13	14.00
$14\frac{1}{2}$	2.72	3.63	4.53	5.44	6.34	7.25	8.16	9.06	9.97	10.88	11.78	12.69	13.59	14.50
15	2.81	3.75	4.69	5.63	6.56	7.50	8.44	9.38	10.31	11.25	12.19	13.13	14.06	15.00
$15\frac{1}{2}$	2.91	3.88	4.84	5.81	6.78	7.75	8.72	9.69	10.66	11.63	12.59	13.56	14.53	15.50
16	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00
$16\frac{1}{2}$	3.09	4.13	5.16	6.19	7.22	8.25	9.28	10.31	11.34	12.38	13.41	14.44	15.47	16.50
17	3.19	4.25	5.31	6.38	7.44	8.50	9.56	10.63	11.69	12.75	13.81	14.88	15.94	17.00
$17\frac{1}{2}$	3.28	4.38	5.47	6.56	7.66	8.75	9.84	10.94	12.03	13.13	14.22	15.31	16.41	17.50
18	3.38	4.50	5.63	6.75	7.88	9.00	10.13	11.25	12.38	13.50	14.63	15.75	16.88	18.00
$18\frac{1}{2}$	3.47	4.63	5.78	6.94	8.09	9.25	10.41	11.56	12.72	13.88	15.03	16.19	17.34	18.50
19	3.56	4.75	5.94	7.13	8.31	9.50	10.69	11.88	13.06	14.25	15.44	16.63	17.81	19.00
$19\frac{1}{2}$	3.66	4.88	6.09	7.31	8.53	9.75	10.97	12.19	13.41	14.63	15.84	17.06	18.28	19.50
20	3.75	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00	16.25	17.50	18.75	20.00
$20\frac{1}{2}$	3.84	5.13	6.41	7.69	8.97	10.25	11.53	12.81	14.09	15.38	16.66	17.94	19.22	20.50
21	3.94	5.25	6.56	7.88	9.19	10.50	11.81	13.13	14.44	15.75	17.06	18.38	19.69	21.00
$21\frac{1}{2}$	4.03	5.38	6.72	8.06	9.41	10.75	12.09	13.44	14.78	16.13	17.47	18.81	20.16	21.50
22	4.13	5.50	6.88	8.25	9.63	11.00	12.38	13.75	15.13	16.50	17.88	19.25	20.63	22.00
$22\frac{1}{2}$	4.22	5.63	7.03	8.44	9.84	11.25	12.66	14.06	15.47	16.88	18.28	19.69	21.09	22.50
23	4.31	5.75	7.19	8.63	10.06	11.50	12.94	14.38	15.81	17.25	18.69	20.13	21.56	23.00
$23\frac{1}{2}$	4.41	5.88	7.34	8.81	10.28	11.75	13.22	14.69	16.16	17.63	19.09	20.56	22.03	23.50
24	4.50	6.00	7.50	9.00	10.50	12.00	13.50	15.00	16.50	18.00	19.50	21.00	22.50	24.00
25	4.69	6.25	7.81	9.38	10.94	12.50	14.06	15.63	17.19	18.75	20.31	21.88	23.44	25.00
26	4.88	6.50	8.13	9.75	11.38	13.00	14.63	16.25	17.88	19.50	21.13	22.75	24.38	26.00
27	5.06	6.75	8.44	10.13	11.81	13.50	15.19	16.88	18.56	20.25	21.94	23.63	25.31	27.00
28	5.25	7.00	8.75	10.50	12.25	14.00	15.75	17.50	19.25	21.00	22.75	24.50	26.25	28.00
29	5.44	7.25	9.06	10.88	12.69	14.50	16.31	18.13	19.94	21.75	23.56	25.38	27.19	29.00
30	5.63	7.50	9.38	11.25	13.13	15.00	16.88	18.75	20.63	22.50	24.38	26.25	28.13	30.00
31	5.81	7.75	9.69	11.63	13.56	15.50	17.44	19.38	21.31	23.25	25.19	27.13	29.06	31.00
32	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00

AREA OF RECTANGULAR SECTIONS

SQUARE INCHES

Width In.	Thickness, Inches													
	3⁄16	1⁄4	5⁄16	3⁄8	7⁄16	1⁄2	9⁄16	5⁄8	11⁄16	3⁄4	13⁄16	7⁄8	15⁄16	1
33	6.19	8.25	10.31	12.38	14.44	16.50	18.56	20.63	22.69	24.75	26.81	28.88	30.94	33.00
34	6.38	8.50	10.63	12.75	14.88	17.00	19.13	21.25	23.38	25.50	27.63	29.75	31.88	34.00
35	6.56	8.75	10.94	13.13	15.31	17.50	19.69	21.88	24.06	26.25	28.44	30.63	32.81	35.00
36	6.75	9.00	11.25	13.50	15.75	18.00	20.25	22.50	24.75	27.00	29.25	31.50	33.75	36.00
37	6.94	9.25	11.56	13.88	16.19	18.50	20.81	23.13	25.44	27.75	30.06	32.38	34.69	37.00
38	7.13	9.50	11.88	14.25	16.63	19.00	21.38	23.75	26.13	28.50	30.88	33.25	35.63	38.00
39	7.31	9.75	12.19	14.63	17.06	19.50	21.94	24.38	26.81	29.25	31.69	34.13	36.56	39.00
40	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00
41	7.69	10.25	12.81	15.38	17.94	20.50	23.06	25.63	28.19	30.75	33.31	35.88	38.44	41.00
42	7.88	10.50	13.13	15.75	18.38	21.00	23.63	26.25	28.88	31.50	34.13	36.75	39.38	42.00
43	8.06	10.75	13.44	16.13	18.81	21.50	24.19	26.88	29.56	32.25	34.94	37.63	40.31	43.00
44	8.25	11.00	13.75	16.50	19.25	22.00	24.75	27.50	30.25	33.00	35.75	38.50	41.25	44.00
45	8.44	11.25	14.06	16.88	19.69	22.50	25.31	28.13	30.94	33.75	36.56	39.38	42.19	45.00
46	8.63	11.50	14.38	17.25	20.13	23.00	25.88	28.75	31.63	34.50	37.38	40.25	43.13	46.00
47	8.81	11.75	14.69	17.63	20.56	23.50	26.44	29.38	32.31	35.25	38.19	41.13	44.06	47.00
48	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	39.00	42.00	45.00	48.00
49	9.19	12.25	15.31	18.38	21.44	24.50	27.56	30.63	33.69	36.75	39.81	42.88	45.94	49.00
50	9.38	12.50	15.63	18.75	21.88	25.00	28.13	31.25	34.38	37.50	40.63	43.75	46.88	50.00
51	9.56	12.75	15.94	19.13	22.31	25.50	28.69	31.88	35.06	38.25	41.44	44.63	47.81	51.00
52	9.75	13.00	16.25	19.50	22.75	26.00	29.25	32.50	35.75	39.00	42.25	45.50	48.75	52.00
53	9.94	13.25	16.56	19.88	23.19	26.50	29.81	33.13	36.44	39.75	43.06	46.38	49.69	53.00
54	10.13	13.50	16.88	20.25	23.63	27.00	30.38	33.75	37.13	40.50	43.88	47.25	50.63	54.00
55	10.31	13.75	17.19	20.63	24.06	27.50	30.94	34.38	37.81	41.25	44.69	48.13	51.56	55.00
56	10.50	14.00	17.50	21.00	24.50	28.00	31.50	35.00	38.50	42.00	45.50	49.00	52.50	56.00
57	10.69	14.25	17.81	21.38	24.94	28.50	32.06	35.63	39.19	42.75	46.31	49.88	53.44	57.00
58	10.88	14.50	18.13	21.75	25.38	29.00	32.63	36.25	39.88	43.50	47.13	50.75	54.38	58.00
59	11.06	14.75	18.44	22.13	25.81	29.50	33.19	36.88	40.56	44.25	47.94	51.63	55.31	59.00
60	11.25	15.00	18.75	22.50	26.25	30.00	33.75	37.50	41.25	45.00	48.75	52.50	56.25	60.00
61	11.44	15.25	19.06	22.88	26.69	30.50	34.31	38.13	41.94	45.75	49.56	53.38	57.19	61.00
62	11.63	15.50	19.38	23.25	27.13	31.00	34.88	38.75	42.63	46.50	50.38	54.25	58.13	62.00
63	11.81	15.75	19.69	23.63	27.56	31.50	35.44	39.38	43.31	47.25	51.19	55.13	59.06	63.00
64	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	44.00	48.00	52.00	56.00	60.00	64.00
65	12.19	16.25	20.31	24.38	28.44	32.50	36.56	40.63	44.69	48.75	52.81	56.88	60.94	65.00
66	12.38	16.50	20.63	24.75	28.88	33.00	37.13	41.25	45.38	49.50	53.63	57.75	61.88	66.00
67	12.56	16.75	20.94	25.13	29.31	33.50	37.69	41.88	46.06	50.25	54.44	58.63	62.81	67.00
68	12.75	17.00	21.25	25.50	29.75	34.00	38.25	42.50	46.75	51.00	55.25	59.50	63.75	68.00
69	12.94	17.25	21.56	25.88	30.19	34.50	38.81	43.13	47.44	51.75	56.06	60.38	64.69	69.00
70	13.13	17.50	21.88	26.25	30.63	35.00	39.38	43.75	48.13	52.50	56.88	61.25	65.63	70.00
71	13.31	17.75	22.19	26.63	31.06	35.50	39.94	44.38	48.81	53.25	57.69	62.13	66.56	71.00
72	13.50	18.00	22.50	27.00	31.50	36.00	40.50	45.00	49.50	54.00	58.50	63.00	67.50	72.00

AREA OF RECTANGULAR SECTIONS

SQUARE INCHES

Width In.	Thickness, Inches													
	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
73	13.69	18.25	22.81	27.38	31.94	36.50	41.06	45.63	50.19	54.75	59.31	63.88	68.44	73.00
74	13.88	18.50	23.13	27.75	32.38	37.00	41.63	46.25	50.88	55.50	60.13	64.75	69.38	74.00
75	14.06	18.75	23.44	28.13	32.81	37.50	42.19	46.88	51.56	56.25	60.94	65.63	70.31	75.00
76	14.25	19.00	23.75	28.50	33.25	38.00	42.75	47.50	52.25	57.00	61.75	66.50	71.25	76.00
77	14.44	19.25	24.06	28.88	33.69	38.50	43.31	48.13	52.94	57.75	62.56	67.38	72.19	77.00
78	14.63	19.50	24.38	29.25	34.13	39.00	43.88	48.75	53.63	58.50	63.38	68.25	73.13	78.00
79	14.81	19.75	24.69	29.63	34.56	39.50	44.44	49.38	54.31	59.25	64.19	69.13	74.06	79.00
80	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	55.00	60.00	65.00	70.00	75.00	80.00
81	15.19	20.25	25.31	30.38	35.44	40.50	45.56	50.63	55.69	60.75	65.81	70.88	75.94	81.00
82	15.38	20.50	25.63	30.75	35.88	41.00	46.13	51.25	56.38	61.50	66.63	71.75	76.88	82.00
83	15.56	20.75	25.94	31.13	36.31	41.50	46.69	51.88	57.06	62.25	67.44	72.63	77.81	83.00
84	15.75	21.00	26.25	31.50	36.75	42.00	47.25	52.50	57.75	63.00	68.25	73.50	78.75	84.00
85	15.94	21.25	26.56	31.88	37.19	42.50	47.81	53.13	58.44	63.75	69.06	74.38	79.69	85.00
86	16.13	21.50	26.88	32.25	37.63	43.00	48.38	53.75	59.13	64.50	69.88	75.25	80.63	86.00
87	16.31	21.75	27.19	32.63	38.06	43.50	48.94	54.38	59.81	65.25	70.69	76.13	81.56	87.00
88	16.50	22.00	27.50	33.00	38.50	44.00	49.50	55.00	60.50	66.00	71.50	77.00	82.50	88.00
89	16.69	22.25	27.81	33.38	38.94	44.50	50.06	55.63	61.19	66.75	72.31	77.88	83.44	89.00
90	16.88	22.50	28.13	33.75	39.38	45.00	50.63	56.25	61.88	67.50	73.13	78.75	84.38	90.00
91	....	22.75	28.44	34.13	39.81	45.50	51.19	56.88	62.56	68.25	73.94	79.63	85.31	91.00
92	....	23.00	28.75	34.50	40.25	46.00	51.75	57.50	63.25	69.00	74.75	80.50	86.25	92.00
93	....	23.25	29.06	34.88	40.69	46.50	52.31	58.13	63.94	69.75	75.56	81.38	87.19	93.00
94	....	23.50	29.38	35.25	41.13	47.00	52.88	58.75	64.63	70.50	76.38	82.25	88.13	94.00
95	....	23.75	29.69	35.63	41.56	47.50	53.44	59.38	65.31	71.25	77.19	83.13	89.06	95.00
96	....	24.00	30.00	36.00	42.00	48.00	54.00	60.00	66.00	72.00	78.00	84.00	90.00	96.00
98	....	24.50	30.63	36.75	42.88	49.00	55.13	61.25	67.38	73.50	79.63	85.75	91.88	98.00
100	....	25.00	31.25	37.50	43.75	50.00	56.25	62.50	68.75	75.00	81.25	87.50	93.75	100.00
102	....	25.50	31.88	38.25	44.63	51.00	57.38	63.75	70.13	76.50	82.88	89.25	95.63	102.00
104	....	26.00	32.50	39.00	45.50	52.00	58.50	65.00	71.50	78.00	84.50	91.00	97.50	104.00
106	....	26.50	33.13	39.75	46.38	53.00	59.63	66.25	72.88	79.50	86.13	92.75	99.38	106.00
108	....	27.00	33.75	40.50	47.25	54.00	60.75	67.50	74.25	81.00	87.75	94.50	101.25	108.00
110	....	27.50	34.38	41.25	48.13	55.00	61.88	68.75	75.63	82.50	89.38	96.25	103.13	110.00
112	....	28.00	35.00	42.00	49.00	56.00	63.00	70.00	77.00	84.00	91.00	98.00	105.00	112.00
114	....	28.50	35.63	42.75	49.88	57.00	64.13	71.25	78.38	85.50	92.63	99.75	106.88	114.00
116	....	29.00	36.25	43.50	50.75	58.00	65.25	72.50	79.75	87.00	94.25	101.50	108.75	116.00
118	....	29.50	36.88	44.25	51.63	59.00	66.38	73.75	81.13	88.50	95.88	103.25	110.63	118.00
120	....	30.00	37.50	45.00	52.50	60.00	67.50	75.00	82.50	90.00	97.50	105.00	112.50	120.00
122	....	30.50	38.13	45.75	53.38	61.00	68.63	76.25	83.88	91.50	99.13	106.75	114.38	122.00
124	....	31.00	38.75	46.50	54.25	62.00	69.75	77.50	85.25	93.00	100.75	108.50	116.25	124.00
126	....	31.50	39.38	47.25	55.13	63.00	70.88	78.75	86.63	94.50	102.38	110.25	118.13	126.00
128	....	32.00	40.00	48.00	56.00	64.00	72.00	80.00	88.00	96.00	104.00	112.00	120.00	128.00

ECONOMY OF SHAPES USED AS BEAMS

SECTION MODULUS TABLE

When a simply supported beam is designed to carry a uniform load per lineal foot over its full length, or a single concentrated load at mid-span, the required beam may best be selected by reference to the tables of allowable loads on beams, pages 175 to 195; particularly since those tables show the shear capacity and the necessary end connections or end bearings.

In all other cases it is convenient to calculate the required Section Modulus and, knowing this, to select the beam from the table which follows on pages 84 and 85.

This table includes wide-flange beams, standard beams and channels, light beams rolled on wide flange mills, and other miscellaneous beams, all in the "Regular Series", pages 12 to 55.

The following symbols are used:

I =	American Standard I Beams	Rolled by all structural mills.
⊔ =	American Standard Channels	Rolled by all structural mills.
WF =	Wide Flange Beams	Rolled only by Bethlehem Steel Co., U. S. Steel Corp. and Inland Steel Co.
B =	Miscellaneous Beams	Rolled by Bethlehem Steel Co., U. S. Steel Corp. and Inland Steel Co.
M =	Miscellaneous Beams	Rolled by United States Steel Corporation, Phoenix Iron Company, or Inland Steel Company.
Jr =	Junior Beams and Channels	Rolled by Jones & Laughlin Steel Corp.

The method of using the table is as follows:

Find, in the column headed "Section Modulus", the value equal to, or next larger than, the Section Modulus required.

The beam opposite this value, in the adjoining column, and all beams above it, have a sufficient Section Modulus.

If the first (lowest) of these appears in bold-faced type, it is the lightest beam that will serve. Otherwise, the first beam higher up, that appears in bold-faced type, is the lightest beam that will serve.

If conditions require that the beam must not exceed a certain depth, proceed up the column until a beam within the required depth is reached. (Check to see that no lighter beam of the same depth appears higher up.)

EXAMPLE: Required, a beam with Section Modulus not less than 250 in.^{3}.

The next higher section modulus tabulated is 250.9. This corresponds to 24 I 120.

However, this beam is not in bold-face. The first higher beam in bold-face is 27 WF 102.

1. If 27 in. is not too deep, use 27 WF 102.
2. If 27 in. is too deep but 24 in. will do, use 24 WF 110.
3. If a still shallower beam is required, there will be found, proceeding upward from the starting point, 12 WF 190 and 21 WF 127.

A check should be made for web capacity in shear. Also proper provision must be made in cases of eccentricity or other special conditions of loading.

It is assumed in this table that the beam is to be supported laterally. Otherwise consult the text and charts for laterally unsupported beams, pages 202 to 206.

SECTION MODULUS TABLE

FOR SHAPES USED AS BEAMS

Section Modulus	Shape	Section Modulus	Shape	Section Modulus	Shape
1105.1	36 WF 300	220.9	**24 WF 94**	98.2	**18 WF 55**
1031.2	36 WF 280	220.1	18 WF 114	97.5	12 WF 72
951.1	36 WF 260	216.0	14 WF 136	94.1	16 WF 58
892.5	36 WF 245	202.2	18 WF 105	92.2	14 WF 61
		202.0	14 WF 127		
835.5	**36 WF 230**	197.6	21 WF 96	89.0	**18 WF 50**
811.1	33 WF 240	197.6	24 I 100	88.4	18 I 54.7
				88.0	12 WF 65
740.6	**33 WF 220**	196.3	**24 WF 84**	86.1	10 WF 77
		189.4	14 WF 119		
669.6	**33 WF 200**	185.8	24 I 90	80.7	**16 WF 50**
		184.4	18 WF 96	80.1	10 WF 72
663.6	**36 WF 194**	182.5	12 WF 133	78.1	12 WF 58
649.9	30 WF 210	176.3	14 WF 111	77.8	14 WF 53
				74.5	18 ⊔ 58
621.2	**36 WF 182**	175.4	**24 WF 76**	73.7	10 WF 66
586.1	30 WF 190	173.9	24 I 79.9		
		168.0	21 WF 82	72.4	**16 WF 45**
579.1	**36 WF 170**	166.1	16 WF 96	70.7	12 WF 53
		163.6	14 WF 103	70.2	14 WF 48
541.0	**36 WF 160**	163.4	12 WF 120	69.1	18 ⊔ 51.9
528.2	30 WF 172	160.0	20 I 95	67.1	10 WF 60
		156.1	18 WF 85	64.7	12 WF 50
502.9	**36 WF 150**	151.3	16 WF 88		
492.8	27 WF 177			64.4	**16 WF 40**
486.4	33 WF 152	150.7	**21 WF 73**	64.2	15 I 50
		150.6	14 WF 95	63.7	18 ⊔ 45.8
446.8	**33 WF 141**	150.2	20 I 85	62.7	14 WF 43
444.5	27 WF 160	144.5	12 WF 106	61.0	18 ⊔ 42.7
413.5	24 WF 160	141.7	18 WF 77	60.4	10 WF 54
				60.4	8 WF 67
404.8	**33 WF 130**	139.9	**21 WF 68**	58.9	15 I 42.9
402.9	27 WF 145	138.1	14 WF 87	58.2	12 WF 45
379.7	30 WF 132	134.7	12 WF 99		
372.5	24 WF 145	130.9	14 WF 84	56.3	**16 WF 36**
		128.2	18 WF 70	54.6	14 WF 38
354.6	**30 WF 124**	127.8	16 WF 78	54.6	10 WF 49
330.7	24 WF 130			53.6	15 ⊔ 50
		126.4	**21 WF 62**	52.0	8 WF 58
327.9	**30 WF 116**	126.3	20 I 75	51.9	12 WF 40
317.2	21 WF 142	126.3	10 WF 112	50.3	12 I 50
		125.0	12 WF 92	49.1	10 WF 45
299.2	**30 WF 108**	121.1	14 WF 78		
299.2	27 WF 114	117.0	18 WF 64	48.5	**14 WF 34**
299.1	24 WF 120	116.9	20 I 65.4	46.2	15 ⊔ 40
284.1	21 WF 127	115.9	16 WF 71	45.9	12 WF 36
274.4	24 WF 110	115.7	12 WF 85	44.8	12 I 40.8
		112.4	10 WF 100	43.2	8 WF 48
266.3	**27 WF 102**	112.3	14 WF 74	42.2	10 WF 39
263.2	12 WF 190				
250.9	24 I 120	107.8	**18 WF 60**	41.8	**14 WF 30**
249.6	21 WF 112	107.1	12 WF 79	41.7	15 ⊔ 33.9
		104.2	16 WF 64	39.4	12 WF 31
248.9	**24 WF 100**	103.0	14 WF 68	37.8	12 I 35
		101.9	18 I 70	36.0	12 I 31.8
242.8	**27 WF 94**	99.7	10 WF 89	35.5	8 WF 40
234.3	24 I 105.9			35.0	10 WF 33
222.2	12 WF 161				

SECTION MODULUS TABLE

FOR SHAPES USED AS BEAMS

Section Modulus	Shape	Source
34.1	**12 WF 27**	9
31.1	8 WF 35	2
30.8	10 WF 29	9
29.2	10 I 35	1
28.9	8 M 34.3	3
27.4	8 WF 31	2
26.9	12 ⊔ 30	1
26.4	**10 WF 25**	9
25.3	**12 B 22**	9
24.4	10 I 25.4	1
24.3	8 WF 28	2
23.9	12 ⊔ 25	1
21.5	**10 WF 21**	9
21.4	**12 B 19**	9
21.4	12 ⊔ 20.7	1
21.0	8 M 24	6
21.0	**14 B 17.2**	7
20.8	8 WF 24	2
20.6	10 ⊔ 30	1
18.8	10 B 19	9
18.1	10 ⊔ 25	1
17.5	**12 B 16.5**	9
17.0	8 WF 20	9
16.8	6 WF 25	2
16.2	10 B 17	9
16.0	8 I 23	1
15.7	10 ⊔ 20	1
15.7	6 M 25	3
15.2	8 M 20	6

Section Modulus	Shape	Source
14.8	**12 B 14**	8
14.2	8 I 18.4	1
14.1	8 WF 17	9
14.0	8 M 17	6
13.8	10 B 15	9
13.5	9 ⊔ 20	1
13.4	10 ⊔ 15.3	1
13.4	6 WF 20	2
12.9	6 M 20	3
12.0	**12 Jr 11.8**	7
12.0	7 I 20	1
11.8	8 B 15	2
11.3	9 ⊔ 15	1
10.9	8 ⊔ 18.75	1
10.5	**10 B 11.5**	8
10.5	9 ⊔ 13.4	1
10.4	7 I 15.3	1
10.1	6 WF 15.5	2
10.1	6 B 16	2
9.9	8 B 13	2
9.9	5 WF 18.5	2
9.5	5 M 18.9	2
9.3	**12 Jr ⊔ 10.6**	7
9.0	8 ⊔ 13.75	1
8.7	6 I 17.25	1
8.5	5 WF 16	2
8.1	8 ⊔ 11.5	1

Section Modulus	Shape	Source
7.8	**10 Jr 9**	7
7.8	8 B 10	2
7.7	7 ⊔ 14.75	1
7.3	6 I 12.5	1
7.2	6 B 12	2
6.9	7 ⊔ 12.25	1
6.5	**10 Jr ⊔ 8.4**	7
6.0	7 ⊔ 9.8	1
6.0	5 I 14.75	1
5.8	6 ⊔ 13	1
5.4	4 WF 13	5
5.2	4 M 13	4
5.1	6 B 8.5	2
5.0	6 ⊔ 10.5	1
4.8	5 I 10	1
4.7	**8 Jr 6.5**	7
4.4	10 Jr ⊔ 6.5	7
4.3	6 ⊔ 8.2	1
3.5	**7 Jr 5.5**	7
3.5	5 ⊔ 9	1
3.3	4 I 9.5	1
3.0	5 ⊔ 6.7	1
3.0	4 I 7.7	1
2.4	**6 Jr 4.4**	7
2.3	4 ⊔ 7.25	1
1.9	4 ⊔ 5.4	1
1.9	3 I 7.5	1
1.7	3 I 5.7	1
1.4	3 ⊔ 6	1
1.2	**3 ⊔ 5**	1
1.1	**3 ⊔ 4.1**	1

Index to Source Numbers
1. All Structural Mills.
2. U. S. Steel, Bethlehem.
3. U. S. Steel, Inland.
4. U. S. Steel.
5. Bethlehem.
6. Phoenix.
7. Jones & Laughlin.
8. U. S. Steel, Bethlehem, Jones & Laughlin, Inland.
9. U. S. Steel, Bethlehem, Inland.

NOTE: On this page, if the bold-face shape at the head of the group is one which because of its "source" is not available for the particular job, examine the adjacent upper groups for a lighter shape that is available.

USE OF TABLES FOR DESIGN OF PLATE GIRDERS

The American Institute of Steel Construction in 1936 revised its Specification so as to provide for design of plate girders by gross moment of inertia, with certain reservations for special cases. (See Sect. 26(a), page 297.) The attention of the engineering profession was called to this revision, and the reasons therefor, and discussion was invited. The reception of this method having to date been generally favorable, the examples and tables in this Manual have been primarily based upon this Specification. For the benefit, however, of such offices as are still designing under net area rules, the examples and tables have been amplified to assist therein.

Design of a plate girder by moment of inertia necessitates a preliminary design and frequently this will require one or more corrections before it will fully conform to the Specification. For comparatively light girders the design may be taken directly from the tables on pages 102 to 108, by selecting the capacity next greater than the requirement. For greater economy it may be convenient to choose a trial design by interpolation between the designs tabulated. For deeper and heavier girders than those tabulated, it is generally expeditious to select a trial section by the "flange area method" and to check this for moment of inertia. In the following two examples this latter method has been used, although in the first example a close approximation might have been made, as above suggested, by interpolation in the girder tables.

Specification sections controlling a design step are listed at the right of the page. Where information is obtained from data in the Manual, the page number therefor is also given at the right.

EXAMPLE I. Plate Girder without Cover Plates.

Given Conditions:

Max. Bending Moment	1250 ft. kips
Max. Vertical Shear	200 kips
Effective Span	38 ft.
Max. depth, out to out of steel	39 in.
Rivets	¾″ dia.

The compression flange is laterally supported only at the ends and center.

Design by "Flange Area Method."

a. Assume depth of girder $= 38\frac{1}{2}''$ back to back of flange angles.

Web area required $= \dfrac{200}{13} = 15.38$ sq. in. — Sect. 15(a)

Web area furnished $= 38 \times \frac{7}{16} = 16.63$ sq. in. — p. 80

(Assuming flange angles to have 4″ vertical legs — Sect. 26(b)

minimum web thickness $= \dfrac{38.5-(2\times 4)}{170} = 0.179''$, or $\frac{1}{4}''$) — Sect. 18(a)

b. Assume flanges $16\frac{7}{16}''$ wide by $\frac{7}{8}''$ thick

$$\frac{ld}{bt} = \frac{19\times 12\times 38.5}{16\frac{7}{16}\times \frac{7}{8}} = 610 \qquad >600$$ — Sect. 15(a)(3)

Max. allowable unit stress in compression flange $= \dfrac{12{,}000{,}000}{610}$ — "

$= 19.67$ kips per sq. in.

Max. unit stress at c.g. of flange $= \dfrac{19.67\times 36.5}{38.5} = 18.65$ kips per sq. in.

c. Required flange area (including ⅙ web) $= \dfrac{1250\times 12}{36.5\times 18.65} = 22.04$ sq. in.

⅙ gross area of web $= \dfrac{16.63}{6} = 2.77$

Gross flange area required $= 19.27$ sq. in.

d. Flange section furnished $= 2$ angles 8 x 4 x ⅞

Gross area $= 2\times 9.73 = 19.46$ sq. in.

e. Percentage of rivet holes $= \frac{2 \times 7/8 \times 7/8}{19.46} \times 100 = 7.9 < 15\%$

No increase in gross area necessary.

f. Trial girder section: 1 Web 38 x 7/16
4 Angles 8 x 4 x 7/8

Check by "Moment of Inertia Method."

Section	A in.^{2}	y in.	Ay^2 in.^{4}	I_o in.^{4}	I gr. in.^{4}	
1 web 38 x 7/16	16.63	—	—	2000	2000	p. 90
4 angles 8 x 4 x 7/8	38.92	18.25	12 960†	42	13 002	p. 96

See foot note for notation.

Gross Area = 55.55 sq. in. Gross I = 15002 in.^{4}

Section Modulus required $= \frac{1250 \times 12}{19.67} = 762$ in.^{3}

Section Modulus furnished $= \frac{15002}{19.25} = 779$ in.^{3}

Check for minimum required rivet pitch to determine if 4" vertical angle legs are satisfactory. (1 gage line)

$v = \frac{VQ}{I} = \frac{200 \times 19.46 \times 18.25}{15002} = 4.73$ kips per linear inch. p. 365

Minimum pitch $= \frac{13.1}{4.73} = 2.78$ in. 3/4" rivs., bearing on 7/16" p. 270

Minimum allowable pitch = 3 rivet diameters = 2 1/4 in. Sect. 23(a)

Section is satisfactory.

Modification if design is based on net area.

Assuming that the bottom flange stress will govern, and assuming that a trial design has been similarly arrived at, but using only 1/8 web area instead of 1/6, then the only change in the check calculations is as follows:

f. Trial girder section: 1 Web 38 x 7/16
4 Angles 8 x 4 x 1

Check by "Moment of Inertia Method."

Section	A in.^{2}	y in.	Ay^2 in.^{4}	I_o in.^{4}	I gr. in.^{4}	I net in.^{4}	
1 web 38 x 7/16	16.63	—	—	2000	2000	16610	p. 90
4 angles 8 x 4 x 1	44.00	18.20	14564‡	46	14610		p. 96
2 holes 7/8 x 2 7/16	–4.27	16.75	1198‡	—	—	1198	

See foot note for notation.

Gross Area = 60.63 sq. in. I gr. = 16610 in.^{4} I net = 15412 in.^{4}

†This may be obtained from the tables on pages 92, and 96, as follows: enter page 92 with d = 38.5—2.0 (from p. 96) = 36.5, reading 666; 2 angles each flange = 19.46 × 666 = 12960.

Notation: A = area, y = distance from neutral axis of the entire section to the center of gravity of the component being considered, I_o = moment of inertia about own axis, I gr. = moment of inertia of gross section, I net = moment of inertia of net section.

‡May be obtained similarly as explained in foot note †.

Section Modulus required $=\frac{1250\times 12}{20}=750$ in.^{3}

Section Modulus furnished $=\frac{15412}{19.25}=800$ in.^{3}

Section is satisfactory.

EXAMPLE II. Plate Girder with Cover Plates.

Given Conditions: Max. Bending Moment .... 5000 ft. kips
Max. Vertical Shear .... 500 kips
Effective Span .... 40 ft.
Max. depth, out to out of steel .... 66 in.
Rivets .... 1″ dia.

The compression flange is laterally supported for the full length of the girder.

Design by "Flange Area Method."

a. Assume total thickness of covers $=2\times1\frac{7}{8}''=3\frac{3}{4}''$
Height of rivet heads $=2\times\frac{11}{16}''=1\frac{3}{8}''$ p. 160

Max. depth back to back of flange angles =
$66-3\frac{3}{4}-1\frac{3}{8}=60\frac{7}{8}''$. Use $60\frac{1}{2}''$.

Web area required $=\frac{500}{13}=38.46$ sq. in. Sect. 15(a)

Web area furnished $=60\times\frac{11}{16}=41.25$ sq. in. p. 80

(Assuming flange angles to have 6″ vertical legs
minimum web thickness $=\frac{60.5-(2\times6)}{170}=.285''$) Sect. 26(b)

b. Assume distance between c.g. of flanges = distance back to back of flange angles = 60.5″ and that distance out to out of steel, excluding rivet heads $=60.5+(2\times1\frac{7}{8})=64.25''$

Max. unit stress at c.g. of flange $=\frac{20\times60.5}{64.25}=18.83$ kips per sq. in.

c. Required flange area (including $\frac{1}{6}$ web) $=\frac{5000\times12}{60.5\times18.83}=52.67$ sq. in.

$\frac{1}{6}$ gross area of web $=\frac{41.25}{6}=\underline{6.87}$

Gross flange area required $=45.80$ sq. in.

d. Flange section furnished = 2 Angles 6x6x1 $=2\times11.00=22.00$ sq. in. p. 32 or 96
2 Cover Plates $14\times\frac{15}{16}=\underline{26.26}$ p. 79 or 95

Gross Flange area $=48.26$ sq. in.

e. Percentage of rivet holes $=\frac{(2\times1\frac{7}{8}\times1\frac{1}{8})+(4\times1\times1\frac{1}{8})}{48.26}\times100=18.07\%$

Reduction in effective area $=\frac{(18.07-15.00)\times48.26}{100}=1.48$ sq. in.

Flange area required $=45.80+1.48=47.28$ sq. in.

f. Trial girder section: 1 Web 60 x $\frac{11}{16}$
4 Angles 6 x 6 x 1
4 Cover Plates 14 x $\frac{15}{16}$

Check by "Moment of Inertia Method."

Section	A in.²	y in.	Ay² in.⁴	I_o in.⁴	I gr. in.⁴	
1 web 60 x 11/16	41.25	—	—	12375	12375	p. 91
4 angles 6 x 6 x 1	44.00	28.39	35464†	142	35606	p. 96
2 cov. pls. 14 x 15/16	26.25	31.19	51082†	—	51082	
2 cov. pls. 14 x 15/16	26.25					

Gross Area = 137.75 sq. in. Gross I = 99063 in.⁴

*Deduction of 1.48 sq. in. in each flange $= 2 \times 1.48 \times \overline{29.75}^2 = 2620$ in.⁴

Effective Moment of Inertia = 96443 in.⁴

Section Modulus required $= \frac{5000 \times 12}{20} = 3000$ in.³

Section Modulus furnished $= \frac{96443}{32.13} = 3002$ in.³

Section is satisfactory.

Modification if design is based on net area.

Assuming that the "Given Conditions" are the same, and that a trial design has been obtained by the flange area method, deducting rivet holes and using 1/8 the gross web as flange area, then the check calculations will be as follows:

f. Trial girder section: 1 web 60 x 11/16
4 Angles 8 x 6 x 1 (60½" b. to b. angles)
4 Cover Plates 18 x 13/16

Check by "Moment of Inertia Method."

Section	A in.²	y in.	Ay² in.⁴	I_o in.⁴	I gr. in.⁴	I net in.⁴	
1 web 60 x 11/16	41.25	—	—	12375	12375		
4 angles 8 x 6 x 1	52.00	28.60	42536†	155	42691	111518	p. 91 p. 96
4 cov. pls. 18 x 13/16	58.50	31.06	56452†	—	56452		
2 holes 1⅛ x 2 11/16	−6.05	27.75	4659†	—	—	15695	
4 holes 1⅛ x 2⅝	−11.81	30.56	11036†	—	—		

Gross Area = 151.75 sq. in.; I gr = 111518 in.⁴ I net = 95823 in.⁴

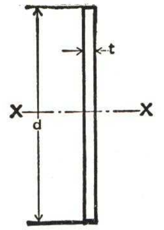
Section Modulus required $= \frac{5000 \times 12}{20} = 3000$ in.³

Section Modulus furnished $= \frac{95823}{31.88} = 3006$ in.³

Section is satisfactory.

†See notes under previous example illustrating the alternative of using the tables on pages 92 to 97 in obtaining these values.

*Flange area to be deducted is assumed concentrated at the c.g. of the outstanding flange legs.



MOMENT OF INERTIA

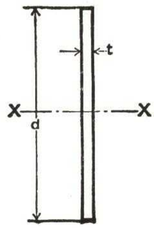
OF ONE PLATE ABOUT AXIS X-X

To obtain the moment of inertia for any thickness of plate not listed below, multiply the value for a plate one inch thick by the desired thickness.

Depth d Inches	Thickness t, Inches							
	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
10	31.3	36.5	41.7	46.9	52.1	62.5	72.9	83.3
11	41.6	48.5	55.5	62.4	69.3	83.2	97.1	110.9
12	54.0	63.0	72.0	81.0	90.0	108.0	126.0	144.0
13	68.7	80.1	91.5	103.0	114.4	137.3	160.2	183.1
14	85.8	100.0	114.3	128.6	142.9	171.5	200.1	228.7
15	105.5	123.0	140.6	158.2	175.8	210.9	246.1	281.3
16	128.0	149.3	170.7	192.0	213.3	256.0	298.7	341.3
17	153.5	179.1	204.7	230.3	255.9	307.1	358.2	409.4
18	182.3	212.6	243.0	273.4	303.8	364.5	425.3	486.0
19	214.3	250.1	285.8	321.5	357.2	428.7	500.1	571.6
20	250.0	291.7	333.3	375.0	416.7	500.0	583.3	666.7
21	289.4	337.6	385.9	434.1	482.3	578.8	675.3	771.8
22	332.8	388.2	443.7	499.1	554.6	665.5	776.4	887.3
23	380.2	443.6	507.0	570.3	633.7	760.4	887.2	1013.9
24	432.0	504.0	576.0	648.0	720.0	864.0	1008.0	1152.0
25	488.3	569.7	651.0	732.4	813.8	976.6	1139.3	1302.1
26	549.3	640.8	732.3	823.9	915.4	1098.5	1281.6	1464.7
27	615.1	717.6	820.1	922.6	1025.2	1230.2	1435.2	1640.3
28	686.0	800.3	914.7	1029.0	1143.3	1372.0	1600.7	1829.3
29	762.2	889.2	1016.2	1143.2	1270.3	1524.3	1778.4	2032.4
30	843.8	984.4	1125.0	1265.6	1406.3	1687.5	1968.8	2250.0
31	931.0	1086.1	1241.3	1396.5	1551.6	1861.9	2172.3	2482.6
32	1024.0	1194.7	1365.3	1536.0	1706.7	2048.0	2389.3	2730.7
33	1123.0	1310.2	1497.4	1684.5	1871.7	2246.1	2620.4	2994.8
34	1228.3	1433.0	1637.7	1842.4	2047.1	2456.5	2865.9	3275.3
35	1339.8	1563.2	1786.5	2009.8	2233.1	2679.7	3126.3	3572.9
36	1458.0	1701.0	1944.0	2187.0	2430.0	2916.0	3402.0	3888.0
37	1582.9	1846.7	2110.5	2374.4	2638.2	3165.8	3693.4	4221.1
38	1714.8	2000.5	2286.3	2572.1	2857.9	3429.5	4001.1	4572.7
39	1853.7	2162.7	2471.6	2780.6	3089.5	3707.4	4325.3	4943.3
40	2000.0	2333.3	2666.7	3000.0	3333.3	4000.0	4666.7	5333.3
41	2153.8	2512.7	2871.7	3230.7	3589.6	4307.6	5025.5	5743.4
42	2315.3	2701.1	3087.0	3472.9	3858.8	4630.5	5402.3	6174.0
43	2484.6	2898.7	3312.8	3726.9	4141.0	4969.2	5797.4	6625.6
44	2662.0	3105.7	3549.3	3993.0	4436.7	5324.0	6211.3	7098.7
45	2847.7	3322.3	3796.9	4271.5	4746.1	5695.3	6644.5	7593.8
46	3041.8	3548.7	4055.7	4562.6	5069.6	6083.5	7097.4	8111.3
47	3244.5	3785.2	4326.0	4866.7	5407.4	6488.9	7570.4	8651.9
48	3456.0	4032.0	4608.0	5184.0	5760.0	6912.0	8064.0	9216.0
49	3676.5	4289.3	4902.0	5514.8	6127.6	7353.1	8578.6	9804.1
50	3906.3	4557.3	5208.3	5859.4	6510.4	7812.5	9114.6	10417
51	4145.3	4836.2	5527.1	6218.0	6908.9	8290.7	9672.5	11054
52	4394.0	5126.3	5858.7	6591.0	7323.3	8788.0	10253	11717
53	4652.4	5427.8	6203.2	6978.6	7754.0	9304.8	10856	12406
54	4920.8	5740.9	6561.0	7381.1	8201.3	9841.5	11482	13122

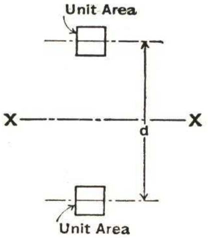
MOMENT OF INERTIA

OF ONE PLATE ABOUT AXIS X-X



To obtain the moment of inertia for any thickness of plate not listed below, multiply the value for a plate one inch thick by the desired thickness.

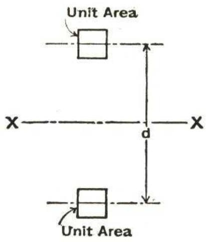
Depth d Inches	Thickness t, Inches							
	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
55	5199.2	6065.8	6932.3	7798.8	8665.4	10398	12132	13865
56	5488.0	6402.7	7317.3	8232.0	9146.7	10976	12805	14635
57	5787.3	6751.8	7716.4	8680.9	9645.5	11575	13504	15433
58	6097.3	7113.5	8129.7	9145.9	10162	12195	14227	16259
59	6418.1	7487.8	8557.5	9627.1	10697	12836	14976	17115
60	6750.0	7875.0	9000.0	10125	11250	13500	15750	18000
61	7093.2	8275.3	9457.5	10640	11822	14186	16551	18915
62	7447.8	8689.0	9930.3	11172	12413	14896	17378	19861
63	7814.0	9116.3	10419	11721	13023	15628	18232	20837
64	8192.0	9557.3	10923	12288	13653	16384	19115	21845
65	8582.0	10012	11443	12873	14303	17164	20025	22885
66	8984.3	10482	11979	13476	14974	17969	20963	23958
67	9398.8	10965	12532	14098	15665	18798	21931	25064
68	9826.0	11464	13101	14739	16377	19652	22927	26203
69	10266	11977	13688	15399	17110	20532	23954	27376
70	10719	12505	14292	16078	17865	21438	25010	28583
72	11664	13608	15552	17496	19440	23328	27216	31104
74	12663	14774	16884	18995	21105	25327	29548	33769
76	13718	16004	18291	20577	22863	27436	32009	36581
78	14830	17301	19773	22245	24716	29660	34603	39546
80	16000	18667	21333	24000	26667	32000	37333	42667
82	17230	20102	22974	25845	28717	34461	40204	45947
84	18522	21609	24696	27783	30870	37044	43218	49392
86	19877	23190	26502	29815	33128	39754	46379	53005
88	21296	24845	28395	31944	35493	42592	49691	56789
90	22781	26578	30375	34172	37969	45563	53156	60750
92	24334	28390	32445	36501	40557	48668	56779	64891
94	25956	30282	34608	38934	43260	51912	60563	69215
96	27648	32256	36864	41472	46080	55296	64512	73728
98	29412	34314	39216	44118	49020	58825	68629	78433
100	31250	36458	41667	46875	52083	62500	72917	83333
102	33163	38690	44217	49744	55271	66326	77380	88434
104	35152	41011	46869	52728	58587	70304	82021	93739
106	37219	43422	49626	55829	62032	74439	86845	99251
108	39366	45927	52488	59049	65610	78732	91854	104976
110	41594	48526	55458	62391	69323	83188	97052	110917
112	43904	51221	58539	65856	73173	87808	102443	117077
114	46298	54015	61731	69447	77164	92597	108029	123462
116	48778	56908	65037	73167	81297	97556	113815	130075
118	51345	59902	68460	77017	85575	102690	119804	136919
120	54000	63000	72000	81000	90000	108000	126000	144000
122	56745	66203	75660	85118	94575	113491	132406	151321
124	59582	69512	79443	89373	99303	119164	139025	158885
126	62512	72930	83349	93768	104186	125024	145861	166698
128	65536	76459	87381	98304	109227	131072	152917	174763



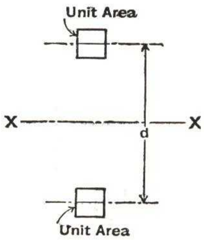
MOMENT OF INERTIA
OF
A PAIR OF UNIT AREAS ABOUT AXIS X-X

d	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
10	50	51	52	53	54	55	56	57	58	59
11	61	62	63	64	65	66	67	68	70	71
12	72	73	74	76	77	78	79	81	82	83
13	85	86	87	88	90	91	92	94	95	97
14	98	99	101	102	104	105	107	108	110	111
15	113	114	116	117	119	120	122	123	125	126
16	128	130	131	133	134	136	138	139	141	143
17	145	146	148	150	151	153	155	157	158	160
18	162	164	166	167	169	171	173	175	177	179
19	181	182	184	186	188	190	192	194	196	198
20	200	202	204	206	208	210	212	214	216	218
21	221	223	225	227	229	231	233	235	238	240
22	242	244	246	249	251	253	255	258	260	262
23	265	267	269	271	274	276	278	281	283	286
24	288	290	293	295	298	300	303	305	308	310
25	313	315	318	320	323	325	328	330	333	335
26	338	341	343	346	348	351	354	356	359	362
27	365	367	370	373	375	378	381	384	386	389
28	392	395	398	400	403	406	409	412	415	418
29	421	423	426	429	432	435	438	441	444	447
30	450	453	456	459	462	465	468	471	474	477
31	481	484	487	490	493	496	499	502	506	509
32	512	515	518	522	525	528	531	535	538	541
33	545	548	551	554	558	561	564	568	571	575
34	578	581	585	588	592	595	598	602	606	609
35	613	616	620	623	627	630	634	637	641	644
36	648	652	655	659	662	666	670	673	677	681
37	685	688	692	696	699	703	707	711	714	718
38	722	726	730	733	737	741	745	749	753	757
39	761	764	768	772	776	780	784	788	792	796
40	800	804	808	812	816	820	824	828	832	836
41	841	845	849	853	857	861	865	869	874	878
42	882	886	890	895	899	903	907	912	916	920
43	925	929	933	937	942	946	950	955	959	964
44	968	972	977	981	986	990	995	999	1004	1008
45	1013	1017	1022	1026	1031	1035	1040	1044	1049	1053
46	1058	1063	1067	1072	1076	1081	1086	1090	1095	1100
47	1105	1109	1114	1119	1123	1128	1133	1138	1142	1147
48	1152	1157	1162	1166	1171	1176	1181	1186	1191	1196
49	1201	1205	1210	1215	1220	1225	1230	1235	1240	1245

MOMENT OF INERTIA OF A PAIR OF UNIT AREAS ABOUT AXIS X-X



d	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
50	1250	1255	1260	1265	1270	1275	1280	1285	1290	1295
51	1301	1306	1311	1316	1321	1326	1331	1336	1342	1347
52	1352	1357	1362	1368	1373	1378	1383	1389	1394	1399
53	1405	1410	1415	1420	1426	1431	1436	1442	1447	1453
54	1458	1463	1469	1474	1480	1485	1491	1496	1502	1507
55	1513	1518	1524	1529	1535	1540	1546	1551	1557	1562
56	1568	1574	1579	1585	1590	1596	1602	1607	1613	1619
57	1625	1630	1636	1642	1647	1653	1659	1665	1670	1676
58	1682	1688	1694	1699	1705	1711	1717	1723	1729	1735
59	1741	1746	1752	1758	1764	1770	1776	1782	1788	1794
60	1800	1806	1812	1818	1824	1830	1836	1842	1848	1854
61	1861	1867	1873	1879	1885	1891	1897	1903	1910	1916
62	1922	1928	1934	1941	1947	1953	1959	1966	1972	1978
63	1985	1991	1997	2003	2010	2016	2022	2029	2035	2042
64	2048	2054	2061	2067	2074	2080	2087	2093	2100	2106
65	2113	2119	2126	2132	2139	2145	2152	2158	2165	2171
66	2178	2185	2191	2198	2204	2211	2218	2224	2231	2238
67	2245	2251	2258	2265	2271	2278	2285	2292	2298	2305
68	2312	2319	2326	2332	2339	2346	2353	2360	2367	2374
69	2381	2387	2394	2401	2408	2415	2422	2429	2436	2443
70	2450	2457	2464	2471	2478	2485	2492	2499	2506	2513
71	2521	2528	2535	2542	2549	2556	2563	2570	2578	2585
72	2592	2599	2606	2614	2621	2628	2635	2643	2650	2657
73	2665	2672	2679	2686	2694	2701	2708	2716	2723	2731
74	2738	2745	2753	2760	2768	2775	2783	2790	2798	2805
75	2813	2820	2828	2835	2843	2850	2858	2865	2873	2880
76	2888	2896	2903	2911	2918	2926	2934	2941	2949	2957
77	2965	2972	2980	2988	2995	3003	3011	3019	3026	3034
78	3042	3050	3058	3065	3073	3081	3089	3097	3105	3113
79	3121	3128	3136	3144	3152	3160	3168	3176	3184	3192
80	3200	3208	3216	3224	3232	3240	3248	3256	3264	3272
81	3281	3289	3297	3305	3313	3321	3329	3337	3346	3354
82	3362	3370	3378	3387	3395	3403	3411	3420	3428	3436
83	3445	3453	3461	3469	3478	3486	3494	3503	3511	3520
84	3528	3536	3545	3553	3562	3570	3579	3587	3596	3604
85	3613	3621	3630	3638	3647	3655	3664	3672	3681	3689
86	3698	3707	3715	3724	3732	3741	3750	3758	3767	3776
87	3785	3793	3802	3811	3819	3828	3837	3846	3854	3863
88	3872	3881	3890	3898	3907	3916	3925	3934	3943	3952
89	3961	3969	3978	3987	3996	4005	4014	4023	4032	4041



MOMENT OF INERTIA OF A PAIR OF UNIT AREAS ABOUT AXIS X-X

d	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
90	4050	4059	4068	4077	4086	4095	4104	4113	4122	4131
91	4141	4150	4159	4168	4177	4186	4195	4204	4214	4223
92	4232	4241	4250	4260	4269	4278	4287	4297	4306	4315
93	4325	4334	4343	4352	4362	4371	4380	4390	4399	4409
94	4418	4427	4437	4446	4456	4465	4475	4484	4494	4503
95	4513	4522	4532	4541	4551	4560	4570	4579	4589	4598
96	4608	4618	4627	4637	4646	4656	4666	4675	4685	4695
97	4705	4714	4724	4734	4743	4753	4763	4773	4782	4792
98	4802	4812	4822	4831	4841	4851	4861	4871	4881	4891
99	4901	4910	4920	4930	4940	4950	4960	4970	4980	4990
100	5000	5010	5020	5030	5040	5050	5060	5070	5080	5090
101	5101	5111	5121	5131	5141	5151	5161	5171	5182	5192
102	5202	5212	5222	5233	5243	5253	5263	5274	5284	5294
103	5305	5315	5325	5335	5346	5356	5366	5377	5387	5398
104	5408	5418	5429	5439	5450	5460	5471	5481	5492	5502
105	5513	5523	5534	5544	5555	5565	5576	5586	5597	5607
106	5618	5629	5639	5650	5660	5671	5682	5692	5703	5714
107	5725	5735	5746	5757	5767	5778	5789	5800	5810	5821
108	5832	5843	5854	5864	5875	5886	5897	5908	5919	5930
109	5941	5951	5962	5973	5984	5995	6006	6017	6028	6039
110	6050	6061	6072	6083	6094	6105	6116	6127	6138	6149
111	6161	6172	6183	6194	6205	6216	6227	6238	6250	6261
112	6272	6283	6294	6306	6317	6328	6339	6351	6362	6373
113	6385	6396	6407	6418	6430	6441	6452	6464	6475	6487
114	6498	6509	6521	6532	6544	6555	6567	6578	6590	6601
115	6613	6624	6636	6647	6659	6670	6682	6693	6705	6716
116	6728	6740	6751	6763	6774	6786	6798	6809	6821	6833
117	6845	6856	6868	6880	6891	6903	6915	6927	6938	6950
118	6962	6974	6986	6997	7009	7021	7033	7045	7057	7069
119	7081	7092	7104	7116	7128	7140	7152	7164	7176	7188
120	7200	7212	7224	7236	7248	7260	7272	7284	7296	7308
121	7321	7333	7345	7357	7369	7381	7393	7405	7418	7430
122	7442	7454	7466	7479	7491	7503	7515	7528	7540	7552
123	7565	7577	7589	7601	7614	7626	7638	7651	7663	7676
124	7688	7700	7713	7725	7738	7750	7763	7775	7788	7800
125	7813	7825	7838	7850	7863	7875	7888	7900	7913	7925
126	7938	7951	7963	7976	7988	8001	8014	8026	8039	8052
127	8065	8077	8090	8103	8115	8128	8141	8154	8166	8179
128	8192	8205	8218	8230	8243	8256	8269	8282	8295	8308
129	8321	8333	8346	8359	8372	8385	8398	8411	8424	8437

AREA OF ONE COVER PLATE

GROSS AREA

Plate Width, Inches	Plate Thickness, Inches														
	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1	1 1/8	1 1/4
24	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	27.0	30.0
22	5.5	6.9	8.2	9.6	11.0	12.4	13.7	15.1	16.5	17.9	19.2	20.6	22.0	24.8	27.5
20	5.0	6.2	7.5	8.7	10.0	11.2	12.5	13.7	15.0	16.2	17.5	18.7	20.0	22.5	25.0
18	4.5	5.6	6.7	7.9	9.0	10.1	11.2	12.4	13.5	14.6	15.8	16.9	18.0	20.3	22.5
16	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	18.0	20.0
14	3.5	4.4	5.2	6.1	7.0	7.9	8.7	9.6	10.5	11.4	12.2	13.1	14.0	15.7	17.5
12	3.0	3.7	4.5	5.2	6.0	6.7	7.5	8.2	9.0	9.7	10.5	11.2	12.0	13.5	15.0
10	2.5	3.1	3.7	4.4	5.0	5.6	6.2	6.9	7.5	8.1	8.7	9.4	10.0	11.2	12.5
8	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	9.0	10.0

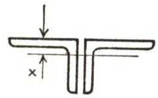
NET AREA

TWO RIVET HOLES DEDUCTED

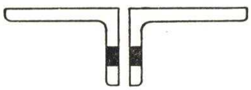
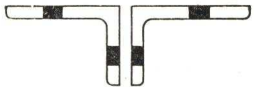
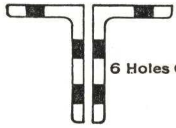
Rivet Diam. In.	Plate Width In.	Plate Thickness, Inches														
		1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1	1 1/8	1 1/4
3/4	16	3.6	4.5	5.3	6.2	7.1	8.0	8.9	9.8	10.7	11.6	12.5	13.4	14.2	16.0	17.8
	14	3.1	3.8	4.6	5.4	6.1	6.9	7.7	8.4	9.2	10.0	10.7	11.5	12.2	13.8	15.3
	12	2.6	3.2	3.8	4.5	5.1	5.8	6.4	7.0	7.7	8.3	9.0	9.6	10.2	11.5	12.8
	10	2.1	2.6	3.1	3.6	4.1	4.6	5.2	5.7	6.2	6.7	7.2	7.7	8.2	9.3	10.3
	8	1.6	2.0	2.3	2.7	3.1	3.5	3.9	4.3	4.7	5.1	5.5	5.9	6.2	7.0	7.8
7/8	18	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	18.0	20.0
	16	3.5	4.4	5.2	6.1	7.0	7.9	8.7	9.6	10.5	11.4	12.2	13.1	14.0	15.7	17.5
	14	3.0	3.7	4.5	5.2	6.0	6.7	7.5	8.2	9.0	9.7	10.5	11.2	12.0	13.5	15.0
	12	2.5	3.1	3.7	4.4	5.0	5.6	6.2	6.9	7.5	8.1	8.7	9.4	10.0	11.2	12.5
	10	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	9.0	10.0
	8	1.5	1.9	2.2	2.6	3.0	3.4	3.7	4.1	4.5	4.9	5.2	5.6	6.0	6.7	7.5
1	22	4.9	6.2	7.4	8.6	9.9	11.1	12.3	13.6	14.8	16.0	17.3	18.5	19.7	22.2	24.7
	20	4.4	5.5	6.7	7.8	8.9	10.0	11.1	12.2	13.3	14.4	15.5	16.6	17.7	20.0	22.2
	18	3.9	4.9	5.9	6.9	7.9	8.9	9.8	10.8	11.8	12.8	13.8	14.8	15.7	17.7	19.7
	16	3.4	4.3	5.2	6.0	6.9	7.7	8.6	9.5	10.3	11.2	12.0	12.9	13.7	15.5	17.2
	14	2.9	3.7	4.4	5.1	5.9	6.6	7.3	8.1	8.8	9.5	10.3	11.0	11.7	13.2	14.7
	12	2.4	3.0	3.7	4.3	4.9	5.5	6.1	6.7	7.3	7.9	8.5	9.1	9.7	11.0	12.2
1 1/8	24	5.4	6.7	8.1	9.4	10.7	12.1	13.4	14.8	16.1	17.5	18.8	20.2	21.5	24.2	26.9
	22	4.9	6.1	7.3	8.5	9.7	11.0	12.2	13.4	14.6	15.8	17.1	18.3	19.5	21.9	24.4
	20	4.4	5.5	6.6	7.7	8.7	9.8	10.9	12.0	13.1	14.2	15.3	16.4	17.5	19.7	21.9
	18	3.9	4.8	5.8	6.8	7.7	8.7	9.7	10.7	11.6	12.6	13.6	14.5	15.5	17.4	19.4
	16	3.4	4.2	5.1	5.9	6.7	7.6	8.4	9.3	10.1	11.0	11.8	12.7	13.5	15.2	16.9
	14	2.9	3.6	4.3	5.0	5.7	6.5	7.2	7.9	8.6	9.3	10.1	10.8	11.5	12.9	14.4
1 1/4	24	5.3	6.6	8.0	9.3	10.6	12.0	13.3	14.6	15.9	17.3	18.6	19.9	21.2	23.9	26.6
	22	4.8	6.0	7.2	8.4	9.6	10.8	12.0	13.2	14.4	15.6	16.8	18.0	19.2	21.7	24.1
	20	4.3	5.4	6.5	7.5	8.6	9.7	10.8	11.9	12.9	14.0	15.1	16.2	17.2	19.4	21.6
	18	3.8	4.8	5.7	6.7	7.6	8.6	9.5	10.5	11.4	12.4	13.3	14.3	15.2	17.2	19.1
	16	3.3	4.1	5.0	5.8	6.6	7.5	8.3	9.1	9.9	10.8	11.6	12.4	13.2	14.9	16.6

Diameter of Hole is assumed 1/8 in. larger than Nominal Diameter of Rivet.

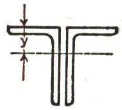
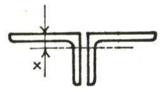
GIRDER FLANGE ANGLES

Size	Thickness	TWO ANGLE	FOUR ANGLES			
		GROSS AREA				
			I-4 Ls	2y	I-4 Ls	2x
	In.	In.^{2}	In.^{4}	In.	In.^{4}	In.
9 x 4	1	24.00	388	7.0	48	2.0
	7/8	21.22	347	6.9	43	1.9
	3/4	18.38	304	6.8	38	1.8
	5/8	15.46	260	6.7	33	1.7
	9/16	14.00	236	6.7	30	1.7
	1/2	12.50	213	6.6	28	1.6
8 x 8	1 1/8	33.46	392	4.8		
	1	30.00	356	4.7		
	7/8	26.46	318	4.6		
	3/4	22.88	279	4.6		
	5/8	19.22	238	4.5		
	9/16	17.36	216	4.4		
	1/2	15.50	195	4.4		
8 x 6	1	26.00	323	5.3	155	3.3
	7/8	22.96	289	5.2	140	3.2
	3/4	19.88	254	5.1	123	3.1
	5/8	16.72	216	5.0	105	3.0
	9/16	15.12	197	5.0	96	3.0
	1/2	13.50	177	4.9	87	2.9
	7/16	11.86	157	4.9	77	2.9
8 x 4	1	22.00	278	6.1	46	2.1
	7/8	19.46	249	6.0	42	2.0
	3/4	16.88	219	5.9	38	1.9
	5/8	14.22	187	5.8	32	1.8
	9/16	12.86	171	5.8	30	1.8
	1/2	11.50	154	5.7	27	1.7
	7/16	10.12	136	5.7	24	1.7
7 x 4	7/8	17.72	172	5.1	41	2.1
	3/4	15.38	151	5.0	36	2.0
	5/8	12.96	130	4.9	31	1.9
	9/16	11.74	118	4.9	29	1.9
	1/2	10.50	107	4.8	26	1.8
	7/16	9.24	95	4.8	23	1.8
	3/8	7.96	82	4.7	20	1.7
6 x 6	1	22.00	142	3.7		
	7/8	19.46	128	3.6		
	3/4	16.88	113	3.6		
	5/8	14.22	97	3.5		
	9/16	12.86	88	3.4		
	1/2	11.50	80	3.4		
	7/16	10.12	71	3.3		
	3/8	8.72	62	3.3		

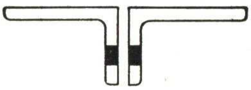
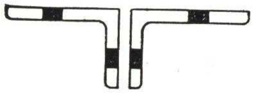
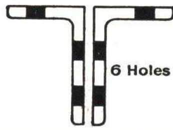
GIRDER FLANGE ANGLES

Size	Thickness	TWO ANGLES—NET AREA											
		 2 Holes Out				 4 Holes Out				 6 Holes Out			
		RIVETS				RIVETS				RIVETS			
	In.	3/4″	7/8″	1″	1 1/8″	3/4″	7/8″	1″	1 1/8″	3/4″	7/8″	1″	1 1/8″
9 x 4	1	22.25	22.00	21.75	21.50	20.50	20.00	19.50	19.00	18.75	18.00	17.25	16.50
	7/8	19.69	19.47	19.25	19.03	18.16	17.72	17.28	16.84	16.63	15.97	15.31	14.66
	3/4	17.07	16.88	16.69	16.50	15.75	15.38	15.00	14.63	14.44	13.88	13.32	12.76
	5/8	14.37	14.21	14.05	13.90	13.27	12.96	12.65	12.33	12.18	11.71	11.24	10.77
	9/16	13.02	12.88	12.73	12.59	12.03	11.75	11.47	11.19	11.05	10.62	10.20	9.78
	1/2	11.62	11.50	11.37	11.25	10.75	10.50	10.25	10.00	9.88	9.50	9.12	8.75
8 x 8	1 1/8	31.49	31.21	30.93	30.65	29.52	28.96	28.40	27.83	27.55	26.71	25.86	25.02
	1	28.25	28.00	27.75	27.50	26.50	26.00	25.50	25.00	24.75	24.00	23.25	22.50
	7/8	24.93	24.71	24.49	24.27	23.40	22.96	22.52	22.08	21.86	21.21	20.56	19.90
	3/4	21.57	21.38	21.19	21.00	20.25	19.88	19.50	19.13	18.94	18.38	17.82	17.25
	5/8	18.13	17.97	17.81	17.66	17.03	16.72	16.41	16.09	15.94	15.47	15.00	14.53
	9/16	16.38	16.23	16.09	15.95	15.39	15.11	14.83	14.55	14.41	13.99	13.57	13.15
	1/2	14.62	14.50	14.37	14.25	13.75	13.50	13.25	13.00	12.87	12.50	12.13	11.75
8 x 6	1	24.25	24.00	23.75	23.50	22.50	22.00	21.50	21.00	20.75	20.00	19.25	18.50
	7/8	21.43	21.21	20.99	20.77	19.90	19.46	19.02	18.58	18.36	17.71	17.06	16.40
	3/4	18.57	18.38	18.19	18.00	17.25	16.88	16.50	16.13	15.94	15.38	14.82	14.25
	5/8	15.63	15.47	15.31	15.16	14.53	14.22	13.91	13.59	13.44	12.97	12.50	12.03
	9/16	14.14	13.99	13.85	13.71	13.15	12.87	12.59	12.31	12.17	11.75	11.32	10.90
	1/2	12.62	12.50	12.37	12.25	11.75	11.50	11.25	11.00	10.87	10.50	10.13	9.75
	7/16	11.09	10.98	10.88	10.77	10.33	10.11	9.89	9.67	9.56	9.24	8.91	8.58
8 x 4	1	20.25	20.00	19.75	19.50	18.50	18.00	17.50	17.00	16.75	16.00	15.25	14.50
	7/8	17.93	17.71	17.49	17.27	16.40	15.96	15.52	15.08	14.86	14.21	13.56	12.90
	3/4	15.57	15.38	15.19	15.00	14.25	13.88	13.50	13.13	12.94	12.38	11.82	11.25
	5/8	13.13	12.97	12.81	12.66	12.03	11.72	11.41	11.10	10.94	10.47	10.00	9.53
	9/16	11.88	11.73	11.59	11.45	10.89	10.61	10.33	10.05	9.90	9.50	9.09	8.64
	1/2	10.62	10.50	10.37	10.25	9.75	9.50	9.25	9.00	8.87	8.50	8.13	7.75
	7/16	9.35	9.24	9.14	9.03	8.59	8.37	8.15	7.93	7.83	7.50	7.18	6.84
7 x 4	7/8	16.19	15.97	15.75	15.53	14.66	14.22	13.78	13.34	13.13	12.47	....	....
	3/4	14.07	13.88	13.69	13.50	12.75	12.38	12.00	11.63	11.44	10.88	....	....
	5/8	11.89	11.73	11.57	11.42	10.79	10.48	10.15	9.84	9.70	9.23	....	....
	9/16	10.76	10.61	10.47	10.33	9.77	9.49	9.21	8.93	8.78	8.38	....	....
	1/2	9.62	9.50	9.37	9.25	8.75	8.50	8.25	8.00	7.87	7.50	....	....
	7/16	8.47	8.36	8.26	8.15	7.71	7.49	7.27	7.05	6.95	6.62	....	....
	3/8	7.32	7.23	7.14	7.04	6.67	6.48	6.27	6.08	6.01	5.73	....	....
6 x 6	1	20.25	20.00	19.75	19.50	18.50	18.00	17.50	17.00	16.75	16.00	....	....
	7/8	17.93	17.71	17.49	17.27	16.40	15.96	15.52	15.08	14.87	14.21	....	....
	3/4	15.57	15.38	15.19	15.00	14.25	13.88	13.50	13.13	12.94	12.38	....	....
	5/8	13.13	12.97	12.81	12.66	12.03	11.72	11.41	11.09	10.94	10.47	....	....
	9/16	11.88	11.73	11.59	11.45	10.89	10.61	10.33	10.05	9.91	9.49	....	....
	1/2	10.62	10.50	10.37	10.25	9.75	9.50	9.25	9.00	8.87	8.50	....	....
	7/16	9.35	9.24	9.14	9.03	8.59	8.37	8.15	7.93	7.82	7.50	....	....
	3/8	8.06	7.97	7.88	7.78	7.41	7.22	7.03	6.84	6.75	6.47	....	....

GIRDER FLANGE ANGLES

Size	Thickness	TWO ANGLES	FOUR ANGLES			
		GROSS AREA				
			I-4 Ls	2y	I-4 Ls	2x
	In.	In.^{2}	In.^{4}	In.	In.^{4}	In.
6 x 4	7/8	15.96	111	4.2	39	2.2
	3/4	13.88	98	4.2	35	2.2
	5/8	11.72	84	4.1	30	2.1
	9/16	10.62	77	4.0	28	2.0
	1/2	9.50	70	4.0	25	2.0
	7/16	8.36	62	3.9	22	1.9
	3/8	7.22	54	3.9	20	1.9
5 x 5	7/8	15.96	71	3.1		
	3/4	13.88	63	3.0		
	5/8	11.72	54	3.0		
	1/2	9.50	45	2.9		
	7/16	8.36	40	2.8		
	3/8	7.22	35	2.8		
6 x 3½	1/2	9.00	66	4.2	17	1.7
	3/8	6.84	52	4.1	13	1.6
	5/16	5.74	44	4.0	11	1.5
5 x 3½	3/4	11.62	56	3.5	22	2.0
	5/8	9.84	48	3.4	19	1.9
	1/2	8.00	40	3.3	16	1.8
	7/16	7.06	36	3.3	14	1.8
	3/8	6.10	31	3.2	13	1.7
	5/16	5.12	26	3.2	11	1.7
5 x 3	1/2	7.50	38	3.5	10	1.5
	3/8	5.72	30	3.4	8	1.4
	5/16	4.80	25	3.4	7	1.4
4 x 4	3/4	10.88	31	2.5		
	5/8	9.22	27	2.5		
	1/2	7.50	22	2.4		
	7/16	6.62	20	2.3		
	3/8	5.72	18	2.3		
	5/16	4.80	15	2.2		
4 x 3½	5/8	8.60	26	2.6	18	2.1
	1/2	7.00	21	2.5	15	2.0
	7/16	6.18	19	2.5	14	2.0
	3/8	5.34	17	2.4	12	1.9
	5/16	4.50	14	2.4	10	1.9
4 x 3	5/8	7.96	24	2.7	12	1.7
	1/2	6.50	20	2.7	10	1.7
	7/16	5.74	18	2.6	9	1.6
	3/8	4.96	16	2.6	8	1.6
	5/16	4.18	14	2.5	7	1.5
	1/4	3.38	11	2.5	6	1.5

GIRDER FLANGE ANGLES

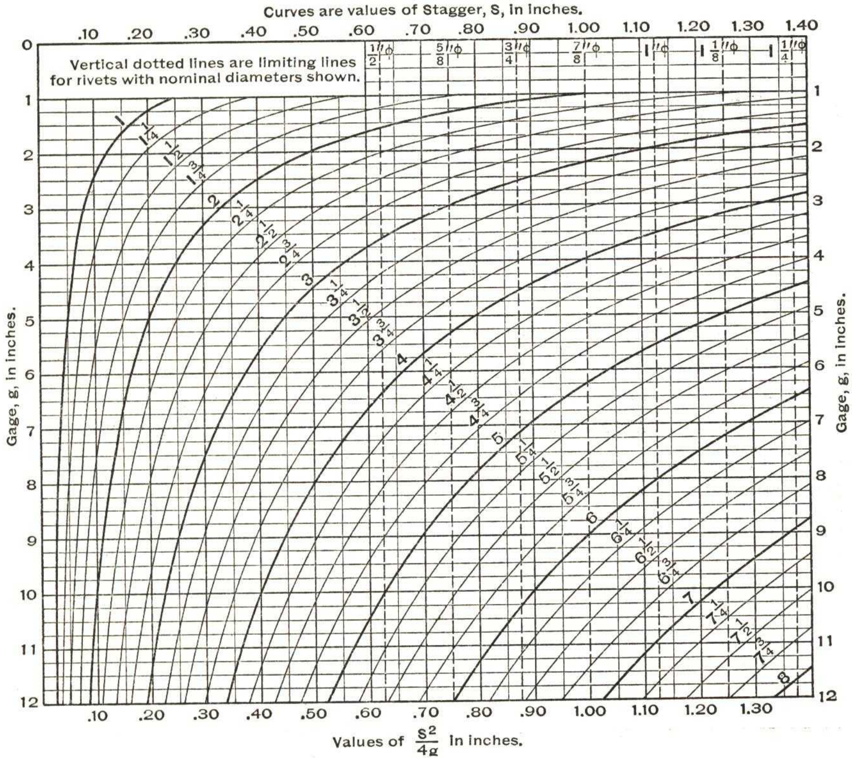
Size	Thickness	TWO ANGLES—NET AREA											
		 2 Holes Out				 4 Holes Out				 6 Holes Out			
		RIVETS				RIVETS				RIVETS			
	In.	¾″	⅞″	1″	1⅛″	¾″	⅞″	1″	1⅛″	¾″	⅞″	1″	1⅛″
6 x 4	⅞	14.43	14.21	13.99	13.77	12.90	12.46	12.02	11.58	11.37			
	¾	12.57	12.38	12.19	12.00	11.25	10.88	10.50	10.13	9.94			
	⅝	10.63	10.47	10.31	10.16	9.53	9.22	8.91	8.60	8.44			
	9/16	9.64	9.49	9.35	9.21	8.65	8.37	8.09	7.81	7.67			
	½	8.62	8.50	8.37	8.25	7.75	7.50	7.25	7.00	6.88			
	7/16	7.59	7.48	7.38	7.27	6.83	6.61	6.39	6.17	6.06			
	⅜	6.56	6.47	6.38	6.28	5.91	5.72	5.53	5.34	5.25			
5 x 5	⅞	14.43	14.21	13.99	13.77	12.90	12.46	12.02	11.58				
	¾	12.57	12.38	12.19	12.00	11.25	10.88	10.50	10.13				
	⅝	10.63	10.47	10.31	10.16	9.53	9.22	8.91	8.59				
	½	8.62	8.50	8.37	8.25	7.75	7.50	7.25	7.00				
	7/16	7.59	7.48	7.38	7.27	6.83	6.61	6.39	6.17				
	⅜	6.56	6.47	6.38	6.28	5.91	5.72	5.53	5.34				
6x3½	½	8.12	8.00	7.87		7.25	7.00			6.38			
	⅜	6.18	6.09	6.00		5.53	5.34			4.87			
	5/16	5.19	5.11	5.04		4.65	4.49			4.10			
5x3½	¾	10.31	10.12	9.93		8.99	8.62						
	⅝	8.75	8.59	8.43		7.65	7.34						
	½	7.12	7.00	6.87		6.25	6.00						
	7/16	6.29	6.18	6.08		5.53	5.31						
	⅜	5.44	5.35	5.26		4.79	4.60						
	5/16	4.57	4.49	4.42		4.03	3.87						
5 x 3	½	6.62	6.50			5.75	5.50						
	⅜	5.06	4.97			4.41	4.22						
	5/16	4.25	4.17			3.71	3.55						
4 x 4	¾	9.57	9.38	9.19	9.00	8.26	7.88						
	⅝	8.13	7.97	7.81	7.66	7.03	6.72						
	½	6.62	6.50	6.37	6.25	5.75	5.50						
	7/16	5.85	5.74	5.64	5.53	5.09	4.87						
	⅜	5.06	4.97	4.88	4.78	4.41	4.22						
	5/16	4.25	4.17	4.10	4.02	3.71	3.55						
4x3½	⅝	7.51	7.35	7.19		6.42	6.10						
	½	6.12	6.00	5.87		5.25	5.00						
	7/16	5.41	5.30	5.20		4.65	4.43						
	⅜	4.68	4.59	4.50		4.03	3.84						
	5/16	3.95	3.87	3.80		3.41	3.25						
4 x 3	⅝	6.87	6.71			5.77	5.46						
	½	5.62	5.50			4.75	4.50						
	7/16	4.97	4.86			4.21	3.99						
	⅜	4.30	4.21			3.65	3.46						
	5/16	3.63	3.55			3.09	2.93						
	¼	2.94	2.88			2.50	2.38						

REDUCTION OF AREA FOR RIVET HOLES

AREA IN SQUARE INCHES = ASSUMED DIAMETER OF HOLE BY THICKNESS OF METAL
FOR COMPUTATION PURPOSES RIVET HOLES SHALL BE TAKEN AT THE NOMINAL DIAMETER OF THE RIVET PLUS 1/8 INCH

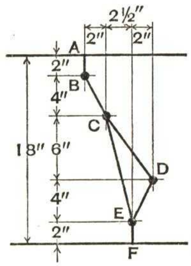
Thickness of Metal Inches	Diameter of Hole, Inches								
	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8
3/16	.117	.141	.164	.188	.211	.234	.258	.281	.305
1/4	.156	.188	.219	.250	.281	.313	.344	.375	.406
5/16	.195	.234	.273	.313	.352	.391	.430	.469	.508
3/8	.234	.281	.328	.375	.422	.469	.516	.563	.609
7/16	.273	.328	.383	.438	.492	.547	.602	.656	.711
1/2	.313	.375	.438	.500	.563	.625	.688	.750	.813
9/16	.352	.422	.492	.563	.633	.703	.773	.844	.914
5/8	.391	.469	.547	.625	.703	.781	.859	.938	1.016
11/16	.430	.516	.602	.688	.773	.859	.945	1.031	1.117
3/4	.469	.563	.656	.750	.844	.938	1.031	1.125	1.219
13/16	.508	.609	.711	.813	.914	1.016	1.117	1.219	1.320
7/8	.547	.656	.766	.875	.984	1.094	1.203	1.313	1.422
15/16	.586	.703	.820	.938	1.055	1.172	1.289	1.406	1.523
1	.625	.750	.875	1.000	1.125	1.250	1.375	1.500	1.625
1 1/16	.664	.797	.930	1.063	1.195	1.328	1.461	1.594	1.727
1 1/8	.703	.844	.984	1.125	1.266	1.406	1.547	1.688	1.828
1 3/16	.742	.891	1.039	1.188	1.336	1.484	1.633	1.781	1.930
1 1/4	.781	.938	1.094	1.250	1.406	1.563	1.719	1.875	2.031
1 5/16		.984	1.148	1.313	1.477	1.641	1.805	1.969	2.133
1 3/8		1.031	1.203	1.375	1.547	1.719	1.891	2.063	2.234
1 7/16		1.078	1.258	1.438	1.617	1.797	1.977	2.156	2.336
1 1/2		1.125	1.313	1.500	1.688	1.875	2.063	2.250	2.438
1 9/16		1.172	1.367	1.563	1.758	1.953	2.148	2.344	2.539
1 5/8		1.219	1.422	1.625	1.828	2.031	2.234	2.438	2.641
1 11/16		1.266	1.477	1.688	1.898	2.109	2.320	2.531	2.742
1 3/4		1.313	1.531	1.750	1.969	2.188	2.406	2.625	2.844
1 13/16			1.586	1.813	2.039	2.266	2.492	2.719	2.945
1 7/8			1.641	1.875	2.109	2.344	2.578	2.813	3.047
1 15/16			1.695	1.938	2.180	2.422	2.664	2.906	3.148
2			1.750	2.000	2.250	2.500	2.750	3.000	3.250
2 1/16			1.805	2.063	2.320	2.578	2.836	3.094	3.352
2 1/8			1.859	2.125	2.391	2.656	2.922	3.188	3.453
2 3/16			1.914	2.188	2.461	2.734	3.008	3.281	3.555
2 1/4			1.969	2.250	2.531	2.813	3.094	3.375	3.656
2 5/16			2.023	2.313	2.602	2.891	3.180	3.469	3.758
2 3/8			2.078	2.375	2.672	2.969	3.266	3.563	3.859
2 7/16			2.133	2.438	2.742	3.047	3.352	3.656	3.961
2 1/2			2.188	2.500	2.813	3.125	3.438	3.750	4.063
2 5/8			2.297	2.625	2.953	3.281	3.609	3.938	4.266
2 3/4			2.406	2.750	3.094	3.438	3.781	4.125	4.469
2 7/8			2.516	2.875	3.234	3.594	3.953	4.313	4.672
3			2.625	3.000	3.375	3.750	4.125	4.500	4.875

NET SECTION OF RIVETED TENSION MEMBERS



The above chart will simplify the application of the rule for net width, Section 19, Pars. (c) and (d) of the Institute Specifications. Entering the chart at left or right with the gauge "g" and proceeding horizontally to intersection with the curve for the pitch "s", thence vertically to top or bottom, the value of s²⁄4g may be read directly.

The example below illustrates the application of the rule, and the use of the chart.



Chain A B C E F		
Deduct for 3 holes @ (¾ + ⅛)	=	—2.625
BC, g = 4, s = 2; add s²⁄4g	=	+0.25
CE, g = 10, s = 2½; add s²⁄4g	=	+0.16
Total Deduction	=	—2.215"
Chain A B C D E F		
Deduct for 4 holes @ (¾ + ⅛)	=	—3.50
BC, as above, add	=	+0.25
CD, g = 6, s = 4½; add s²⁄4g	=	+0.85
DE, g = 4, s = 2; add s²⁄4g	=	+0.25
Total Deduction	=	—2.15"

Net Width = 18.0 — 2.215 = 15.785".

¾" Rivets

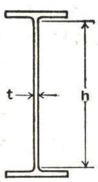
In comparing the path CDE with the path CE, it is seen that if the sum of the two values of s²⁄4g for CD and DE exceed the single value of s²⁄4g for CE, by more than the deduction for one hole, then the path CDE is not critical as compared with CE.

Evidently if the value of s²⁄4g for one leg CD of the path CDE is greater than the deduction for one hole, the path CDE cannot be critical as compared with CE. The vertical dotted lines in the chart serve to indicate, for the respective rivet diameters noted at the top thereof, that any value of s²⁄4g to the right of such line is derived from a non-critical chain which need not be further considered.

DIMENSIONS, WEIGHTS AND PROPERTIES OF PLATE AND ANGLE GIRDERS

These tables of plate girders have been compiled for the purpose of showing certain economies in their use for average spans and relatively light loads.

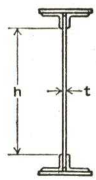
Moments of inertia and section moduli are given for both gross and net flange areas as may be preferred by the designer, although the A. I. S. C. Specification, upon which the tables are based, permits of gross area being used. No provision has been made in spacing of flange rivets for concentrated external loads or forces, and such loads or forces coming upon the girders should be provided for by stiffeners or by other equally effective devices.



ALLOWABLE WEB SHEARS

PER SQUARE INCH FOR UNSTIFFENED WEBS

$$\frac{V}{A} = \left(\frac{8000}{\frac{h}{t}}\right)^2$$



V = Total shear in lbs. [See A. I. S. C. Specification, Sec. 26(b) and (e)] A = Gross area of web in sq. in.

$\frac{h}{t}$	$\frac{V}{A}$ (Kips)	$\frac{h}{t}$	$\frac{V}{A}$ (Kips)	$\frac{h}{t}$	$\frac{V}{A}$ (Kips)	$\frac{h}{t}$	$\frac{V}{A}$ (Kips)	$\frac{h}{t}$	$\frac{V}{A}$ (Kips)	$\frac{h}{t}$	$\frac{V}{A}$ (Kips)
70	13.00	80	10.00	90	7.90	100	6.40	110	5.29	125	4.10
71	12.70	81	9.76	91	7.73	101	6.27	111	5.19	130	3.79
72	12.35	82	9.52	92	7.56	102	6.15	112	5.10	135	3.51
73	12.01	83	9.29	93	7.40	103	6.03	113	5.01	140	3.27
74	11.69	84	9.07	94	7.24	104	5.92	114	4.93	145	3.04
75	11.38	85	8.86	95	7.09	105	5.81	115	4.84	150	2.84
76	11.08	86	8.65	96	6.94	106	5.70	117	4.68	155	2.66
77	10.79	87	8.46	97	6.80	107	5.59	119	4.52	160	2.50
78	10.52	88	8.26	98	6.66	108	5.49	121	4.37	165	2.35
79	10.26	89	8.08	99	6.53	109	5.39	123	4.23	170	2.22

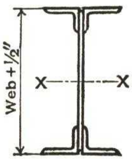


PLATE AND ANGLE GIRDERS

PROPERTIES OF SECTIONS

44

SHORT LEGS CONNECTED TO WEB PLATE

¾″ RIVETS

MATERIALS			Weight per Foot including Rivets	GROSS SECTION			NET SECTION			Maximum Allowable Shear	Rivet Factor
One Web Plate	Four Angles	Two Cover Plates		I_x	S_x	Max. Allowable Moment	I_x	S_x	Max. Allowable Moment		
			Lb.	In.⁴	In.³	Ft. Kips	In.⁴	In.³	Ft. Kips	Kips	In. Kips
43½″ x ⅜″ Web Plate	5 x 3½ x ⅜		100.1	8037	365	608	7249	329	548	107	702
	5 x 3½ x 7/16		106.5	8885	404	673	8010	364	607	107	671
	5 x 3½ x ½		112.9	9705	441	735	8742	398	663	107	648
	5 x 3½ x ⅝		125.7	11312	514	857	10174	462	770	107	615
	5 x 3½ x ¾		137.7	12844	584	973	11531	524	873	107	590
	5 x 3½ x ½	12 x ¼	139.3	12642	568	947	11386	512	853	107	613
	5 x 3½ x ½	12 x ⅜	149.5	14134	632	1053	12660	566	943	107	603
	5 x 3½ x ½	12 x ½	159.7	15646	695	1158	13952	620	1033	107	597
	6 x 4 x ⅜		107.7	8996	409	682	8247	375	625	113	666
	6 x 4 x 7/16		115.7	9996	454	757	9164	417	695	113	640
	6 x 4 x ½		123.3	10984	499	832	10063	457	762	113	620
	6 x 4 x 9/16		130.9	11958	544	907	10954	498	830	113	604
	6 x 4 x ⅝		138.5	12910	587	978	11823	537	895	113	591
	6 x 4 x ¾		152.9	14752	671	1118	13498	613	1022	113	572
	6 x 4 x ⅞		167.3	16528	751	1252	15108	687	1145	113	558
	6 x 4 x ⅝	14 x ½	192.1	19841	882	1470	17943	797	1328	113	593
	6 x 4 x ⅝	14 x ⅝	204.0	21621	956	1593	19506	862	1437	113	590
	6 x 6 x ⅜		119.1	9863	448	747	9095	413	688	143	626
	6 x 6 x 7/16		128.3	11016	501	835	10163	462	770	143	603
	6 x 6 x ½		137.9	12149	552	920	11211	509	848	143	585
	6 x 6 x 9/16		147.1	13252	602	1003	12229	556	927	143	572
	6 x 6 x ⅝		156.3	14354	652	1087	13245	602	1003	143	561
	6 x 6 x ¾		174.3	16488	750	1250	15209	691	1151	143	544
	6 x 6 x ⅞		191.9	18509	841	1402	17059	775	1291	143	531
	6 x 6 x ⅝	14 x ½	209.9	21784	946	1577	19389	862	1437	143	540
	6 x 6 x ⅝	14 x ⅝	221.8	23069	1020	1700	20951	926	1543	143	537

To obtain rivet pitch in any panel divide Rivet Factor by Shear in that panel. CAUTION: Not applicable for rivets carrying both horizontal and vertical shearing stresses.

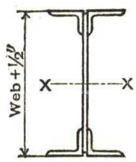
Maximum Allowable Bending Moments are permissible only when compression flange is fully supported laterally.

Weight of rivets is based on spacing of 4 inches

40

PLATE AND ANGLE GIRDERS

PROPERTIES OF SECTIONS



SHORT LEGS CONNECTED TO WEB PLATE

¾'' RIVETS

MATERIALS			Weight per Foot including Rivets	GROSS SECTION			NET SECTION			Maximum Allowable Shear	Rivet Factor
One Web Plate	Four Angles	Two Cover Plates		I_x	S_x	Max. Allowable Moment	I_x	S_x	Max. Allowable Moment		
			Lb.	In.⁴	In.³	Ft. Kips	In.⁴	In.³	Ft. Kips	Kips	In. Kips
39½'' x ⅜'' Web Plate	5 x 3½ x ⅜		94.9	6400	320	533	5762	288	480	122	617
	5 x 3½ x 7/16		101.4	7100	355	592	6391	319	531	122	592
	5 x 3½ x ½		107.8	7773	389	648	6993	349	581	122	573
	5 x 3½ x ⅝		120.6	9087	454	757	8166	408	680	122	546
	5 x 3½ x ¾		132.6	10334	517	862	9271	464	773	122	527
	5 x 3½ x ½	12 x ¼	134.2	10203	504	840	9166	453	755	122	546
	5 x 3½ x ½	12 x ⅜	144.4	11441	562	937	10224	502	836	122	539
	5 x 3½ x ½	12 x ½	154.6	12694	619	1032	11294	551	918	122	535
	6 x 4 x ⅜		101.7	7191	360	600	6588	329	548	130	588
	6 x 4 x 7/16		110.6	8010	400	667	7340	367	611	130	567
	6 x 4 x ½		118.2	8818	441	735	8081	404	673	130	550
	6 x 4 x 9/16		125.8	9613	481	802	8809	440	733	130	537
	6 x 4 x ⅝		133.4	10391	520	867	9520	476	793	130	526
	6 x 4 x ¾		147.8	11899	595	992	10894	545	908	130	510
	6 x 4 x ⅞		162.2	13343	667	1112	12204	610	1016	130	499
	6 x 4 x ⅝	14 x ½	187.0	16132	787	1312	14567	711	1185	130	533
	6 x 4 x ⅝	14 x ⅝	198.9	17611	854	1423	15861	770	1283	130	531
	6 x 6 x ⅜		114.0	7766	388	647	7146	357	595	170	546
	6 x 6 x 7/16		123.2	8804	440	733	8115	406	677	170	534
	6 x 6 x ½		132.8	9725	486	810	8967	448	767	170	520
	6 x 6 x 9/16		142.0	10618	531	885	9791	490	816	170	508
	6 x 6 x ⅝		151.2	11516	576	960	10620	531	885	170	499
	6 x 6 x ¾		169.2	13246	662	1103	12212	611	1018	170	485
	6 x 6 x ⅞		186.8	14917	746	1243	13746	687	1145	170	475
	6 x 6 x ⅝	14 x ½	204.8	17256	841	1402	15694	785	1308	170	484
	6 x 6 x ⅝	14 x ⅝	216.7	18735	908	1513	16979	849	1415	170	482

To obtain rivet pitch in any panel divide Rivet Factor by Shear in that panel. CAUTION: Not applicable for rivets carrying both horizontal and vertical shearing stresses.

Maximum Allowable Bending Moments are permissible only when compression flange is fully supported laterally.

Weight of rivets is based on spacing of 4 inches.

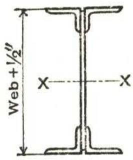


PLATE AND ANGLE GIRDERS

36

PROPERTIES OF SECTIONS

SHORT LEGS CONNECTED TO WEB PLATE

¾" RIVETS

MATERIALS			Weight per Foot including Rivets	GROSS SECTION			NET SECTION			Maximum Allowable Shear	Rivet Factor
One Web Plate	Four Angles	Two Cover Plates		I_x	S_x	Max. Allowable Moment	I_x	S_x	Max. Allowable Moment		
			Lb.	In.⁴	In.³	Ft. Kips	In.⁴	In.³	Ft. Kips	Kips	In. Kips
35½" x ⅜" Web Plate	5 x 3½ x ⅜		89.9	4995	278	463	4491	249	415	143	538
	5 x 3½ x 7/16		96.3	5551	308	513	4991	277	461	143	517
	5 x 3½ x ½		102.7	6088	338	563	5472	304	507	143	501
	5 x 3½ x ⅝		115.5	7138	397	662	6410	356	594	143	479
	5 x 3½ x ¾		127.5	8137	452	753	7297	405	675	143	464
	5 x 3½ x ½	12 x ¼	129.1	8059	442	733	7220	396	660	143	482
	5 x 3½ x ½	12 x ⅜	139.3	9065	493	822	8080	440	733	143	477
	5 x 3½ x ½	12 x ½	149.5	10084	545	909	8950	484	806	143	475
	6 x 4 x ⅜		97.5	5618	312	520	5144	286	476	152	514
	6 x 4 x 7/16		105.5	6275	349	582	5749	319	532	152	496
	6 x 4 x ½		113.1	6921	385	642	6342	352	587	152	482
	6 x 4 x 9/16		120.7	7557	420	700	6926	385	642	152	472
	6 x 4 x ⅝		128.3	8178	454	757	7494	416	694	152	463
	6 x 4 x ¾		142.7	9380	521	868	8591	477	795	152	450
	6 x 4 x ⅞		157.1	10532	585	975	9638	535	892	152	440
	6 x 4 x ⅝	14 x ½	181.9	12841	694	1157	11575	626	1043	152	475
	6 x 4 x ⅝	14 x ⅝	193.8	14047	754	1257	12617	679	1132	152	474
	6 x 6 x ⅜		108.9	6127	340	567	5639	313	522	173	484
	6 x 6 x 7/16		118.1	6873	382	637	6331	352	587	173	468
	6 x 6 x ½		127.7	7603	422	704	7006	390	650	173	456
	6 x 6 x 9/16		136.9	8308	462	770	7657	425	709	173	447
	6 x 6 x ⅝		146.1	9023	501	835	8318	462	770	173	439
	6 x 6 x ¾		164.1	10393	577	962	9579	532	887	173	427
	6 x 6 x ⅞		181.7	11695	650	1083	10773	598	997	173	418
	6 x 6 x ⅝	14 x ½	199.7	13685	739	1232	12422	671	1118	173	429
	6 x 6 x ⅝	14 x ⅝	211.6	14892	799	1332	13474	723	1205	173	428

To obtain rivet pitch in any panel divide Rivet Factor by Shear in that panel. CAUTION: Not applicable for rivets carrying both horizontal and vertical shearing stresses.

Maximum Allowable Bending Moments are permissible only when compression flange is fully supported laterally.

Weight of rivets is based on spacing of 4 inches.

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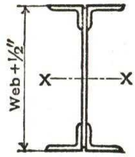
PLATE AND ANGLE GIRDERS

PROPERTIES OF SECTIONS

SHORT LEGS CONNECTED TO WEB PLATE



¾" RIVETS

MATERIALS			Weight per Foot including Rivets	GROSS SECTION			NET SECTION			Maximum Allowable Shear	Rivet Factor
One Web Plate	Four Angles	Two Cover Plates		I_x	S_x	Max. Allowable Moment	I_x	S_x	Max. Allowable Moment		
			Lb.	In.⁴	In.³	Ft. Kips	In.⁴	In.³	Ft. Kips	Kips	In. Kips
31½" x 5/16" Web Plate	4 x 3 x ¼		59.7	2393	150	250	2105	132	220	91	435
	4 x 3 x 5/16		65.3	2762	173	288	2429	152	253	91	407
	4 x 3 x ⅜		70.5	3119	195	325	2742	172	286	91	388
	4 x 3 x 7/16		75.7	3475	217	362	3053	191	318	91	374
	4 x 3 x ½		80.9	3815	238	397	3348	209	348	91	363
	4 x 3 x ⅝		90.9	4470	279	465	3916	245	408	91	344
	4 x 3 x ½	10 x ¼	103.9	5115	315	525	4454	274	457	91	345
	4 x 3 x ½	10 x ⅜	112.4	5781	353	588	5001	305	508	91	340
	4 x 3 x ½	10 x ½	120.9	6455	391	651	5559	337	562	91	337
	5 x 3½ x 5/16		71.3	3178	199	331	2856	178	297	98	384
	5 x 3½ x ⅜		78.1	3623	226	377	3258	204	340	98	368
	5 x 3½ x 7/16		84.5	4056	254	423	3649	228	380	98	356
	5 x 3½ x ½		90.9	4474	280	467	4024	252	420	98	348
	5 x 3½ x ⅝		103.7	5291	331	553	4755	297	495	98	335
	5 x 3½ x ¾		115.7	6065	379	632	5443	340	567	98	326
	5 x 3½ x ½	12 x ¼	117.3	6034	371	618	5373	331	552	98	335
	5 x 3½ x ½	12 x ⅜	127.5	6832	417	695	6052	369	615	98	331
	5 x 3½ x ½	12 x ½	137.7	7642	463	772	6746	408	680	98	328
	6 x 4 x ⅜		85.7	4109	257	428	3770	235	392	107	354
	6 x 4 x 7/16		93.7	4618	289	481	4239	265	441	107	345
	6 x 4 x ½		101.3	5120	320	533	4701	294	490	107	337
	6 x 4 x 9/16		108.9	5614	351	585	5155	322	539	107	331
	6 x 4 x ⅝		116.5	6097	381	635	5598	349	582	107	326
	6 x 4 x ¾		130.9	7028	439	732	6450	403	672	107	318
	6 x 4 x ⅞		145.3	7920	495	825	7263	454	757	107	313
	6 x 4 x ⅝	14 x ½	170.1	9794	594	990	8793	532	887	107	331
	6 x 4 x ⅝	14 x ⅝	182.0	10753	647	1078	9633	579	965	107	329

To obtain rivet pitch in any panel divide Rivet Factor by Shear in that panel. CAUTION: Not applicable for rivets carrying both horizontal and vertical shearing stresses.

Maximum Allowable Bending Moments are permissible only when compression flange is fully supported laterally.

Weight of rivets is based on spacing of 4 inches.

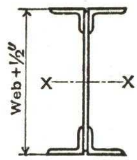


PLATE AND ANGLE GIRDERS

28

PROPERTIES OF SECTIONS

SHORT LEGS CONNECTED TO WEB PLATE

¾" RIVETS

MATERIALS			Weight per Foot including Rivets	GROSS SECTION			NET SECTION			Maximum Allowable Shear	Rivet Factor
One Web Plate	Four Angles	Two Cover Plates		I_x	S_x	Max. Allowable Moment	I_x	S_x	Max. Allowable Moment		
			Lb.	In.⁴	In.³	Ft. Kips	In.⁴	In.³	Ft. Kips	Kips	In. Kips
27½" x 5/16" Web Plate	4 x 3 x ¼		55.4	1736	124	207	1523	109	182	111	363
	4 x 3 x 5/16		61.0	2014	144	240	1768	126	210	111	341
	4 x 3 x ⅜		66.2	2283	163	272	2003	143	238	111	327
	4 x 3 x 7/16		71.4	2551	182	303	2238	160	267	111	316
	4 x 3 x ½		76.6	2806	201	335	2460	176	293	111	307
	4 x 3 x ⅝		86.6	3298	236	393	2887	206	346	111	296
	4 x 3 x ½	10 x ¼	99.6	3804	267	445	3299	232	387	111	295
	4 x 3 x ½	10 x ⅜	108.1	4314	300	500	3719	259	432	111	292
	4 x 3 x ½	10 x ½	116.6	4836	334	557	4150	286	477	111	289
	5 x 3½ x 5/16		67.0	2326	166	277	2090	149	248	112	324
	5 x 3½ x ⅜		73.8	2661	190	317	2393	171	285	112	311
	5 x 3½ x 7/16		80.2	2987	214	357	2688	192	320	112	302
	5 x 3½ x ½		86.6	3300	236	393	2969	212	353	112	296
	5 x 3½ x ⅝		99.4	3912	279	465	3518	251	418	112	286
	5 x 3½ x ¾		111.4	4492	321	535	4035	288	480	112	279
	5 x 3½ x ½	12 x ¼	113.0	4497	316	527	3992	280	467	112	287
	5 x 3½ x ½	12 x ½	123.6	5110	356	593	4515	314	523	112	284
	5 x 3½ x ½	12 x ½	133.8	5736	396	660	5050	348	580	112	283
	6 x 4 x ⅜		81.4	3024	216	360	2778	198	330	112	301
	6 x 4 x 7/16		89.4	3407	243	405	3131	224	373	112	293
	6 x 4 x ½		97.0	3783	270	450	3479	248	413	112	287
	6 x 4 x 9/16		104.6	4153	297	495	3819	272	453	112	282
	6 x 4 x ⅝		112.2	4515	322	537	4153	296	493	112	279
	6 x 4 x ¾		126.6	5210	372	620	4790	342	570	112	273
	6 x 4 x ⅞		141.0	5876	420	700	5399	385	641	112	268
	6 x 4 x ⅝	14 x ½	165.8	7358	507	845	6593	454	756	112	286
	6 x 4 x ⅝	14 x ⅝	177.7	8099	554	923	7241	496	827	112	284

To obtain rivet pitch in any panel divide Rivet Factor by Shear in that panel. CAUTION: Not applicable for rivets carrying both horizontal and vertical shearing stresses.

Maximum Allowable Bending Moments are permissible only when compression flange is fully supported laterally.

Weight of rivets is based on spacing of 4 inches.

PLATE AND ANGLE GIRDERS

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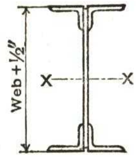
PROPERTIES OF SECTIONS



SHORT LEGS CONNECTED TO WEB PLATE

¾″ RIVETS

MATERIALS			Weight per Foot including Rivets	GROSS SECTION			NET SECTION			Maximum Allowable Shear	Rivet Factor
One Web Plate	Four Angles	Two Cover Plates		I_x	S_x	Max. Allowable Moment	I_x	S_x	Max. Allowable Moment		
			Lb.	In.⁴	In.³	Ft. Kips	In.⁴	In.³	Ft. Kips	Kips	In. Kips
23½″ x 5/16″ Web Plate	4 x 3 x ¼		51.2	1201	100	167	1051	87	145	95	296
	4 x 3 x 5/16		56.8	1401	117	195	1229	102	170	95	280
	4 x 3 x ⅜		61.0	1594	133	222	1399	116	193	95	269
	4 x 3 x 7/16		67.2	1787	149	248	1569	131	218	95	261
	4 x 3 x ½		72.4	1970	164	273	1729	144	240	95	255
	4 x 3 x ⅝		82.4	2322	194	323	2035	169	282	95	246
	4 x 3 x ½	10 x ¼	95.4	2705	221	368	2335	191	318	95	248
	4 x 3 x ½	10 x ⅜	103.9	3084	249	415	2648	214	356	95	245
	4 x 3 x ½	10 x ½	112.4	3470	278	463	2966	237	395	95	243
	5 x 3½ x 5/16		62.8	1624	135	225	1461	122	203	95	267
	5 x 3½ x ⅜		69.6	1865	155	258	1679	140	233	95	257
	5 x 3½ x 7/16		75.8	2098	175	292	1890	158	263	95	251
	5 x 3½ x ½		82.4	2322	194	323	2092	174	290	95	245
	5 x 3½ x ⅝		95.2	2761	230	383	2487	207	390	95	238
	5 x 3½ x ¾		107.2	3172	264	440	2854	238	397	95	233
	5 x 3½ x ½	12 x ¼	108.8	3204	262	464	2834	231	385	95	240
	5 x 3½ x ½	12 x ⅜	119.0	3659	296	493	3222	260	433	95	239
	5 x 3½ x ½	12 x ½	129.2	4123	330	550	3619	289	482	95	238
	6 x 4 x ⅜		77.2	2124	177	295	1956	163	272	95	249
	6 x 4 x 7/16		85.2	2398	200	333	2210	184	306	95	244
	6 x 4 x ½		92.8	2666	222	370	2458	204	340	95	239
	6 x 4 x 9/16		100.4	2931	244	407	2703	225	375	95	236
	6 x 4 x ⅝		108.0	3189	266	443	2941	245	408	95	233
	6 x 4 x ¾		122.4	3683	307	512	3396	283	471	95	228
	6 x 4 x ⅞		136.8	4156	346	577	3829	319	530	95	224
	6 x 4 x ⅝	14 x ½	161.6	5290	423	705	4717	377	628	95	232
	6 x 4 x ⅝	14 x ⅝	173.5	5842	463	772	5212	413	688	95	232

To obtain rivet pitch in any panel divide Rivet Factor by Shear in that panel. CAUTION: Not applicable for rivets carrying both horizontal and vertical shearing stresses.

Maximum Allowable Bending Moments are permissible only when compression flange is fully supported laterally.

Weight of rivets is based on spacing of 4 inches.

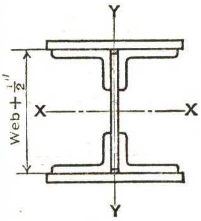


PLATE AND ANGLE COLUMNS

PROPERTIES OF SECTIONS

SHORT LEGS CONNECTED TO WEB PLATE

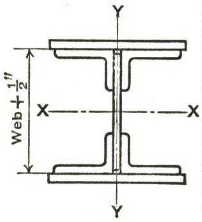
MATERIAL			Total Depth	Weight per Foot	Gross Area	AXIS X-X			AXIS Y-Y		
One Web Plate	Four Angles	Two Cover Plates				I	S	r	I	S	r
			In.	Lb.	In.²	In.⁴	In.³	In.	In.⁴	In.³	In.
16 x 1⅜	8 x 8 x 1⅛	24 x 3¾	24	914	268.9	21808	1817.3	9.01	9677	806.4	6.00
		24 x 3⅝	23¾	894	262.9	20951	1764.3	8.93	9389	782.4	5.98
		24 x 3½	23½	874	256.9	20114	1711.8	8.85	9101	758.4	5.95
		23 x 3½	23½	850	249.9	19407	1651.7	8.81	8135	707.4	5.70
16 x 1⅜	8 x 8 x 1⅛	23 x 3⅜	23¼	830	244.2	18615	1601.3	8.73	7881	685.3	5.68
		23 x 3¼	23	811	238.4	17846	1551.8	8.65	7627	663.2	5.66
		23 x 3⅛	22¾	791	232.7	17095	1502.9	8.57	7374	641.2	5.63
		23 x 3	22½	772	226.9	16358	1454.0	8.49	7120	619.1	5.60
16 x 1⅛	8 x 8 x 1	23 x 3⅛	22¾	754	221.8	16773	1474.5	8.70	7211	627.0	5.70
		23 x 3	22½	734	216.0	16037	1425.5	8.62	6957	605.0	5.67
		22 x 3	22½	714	210.0	15462	1374.4	8.58	6198	563.5	5.43
15 x 1	8 x 6 x 1	22 x 3⅛	21¾	695	204.5	14396	1323.8	8.39	6386	580.5	5.59
		22 x 3	21½	677	199.0	13753	1279.3	8.31	6164	560.4	5.57
	8 x 6 x 1	22 x 2⅞	21¼	658	193.5	13136	1236.3	8.24	5942	540.2	5.54
		22 x 2¾	21	639	188.0	12522	1192.6	8.16	5721	520.1	5.52
		22 x 2⅝	20¾	621	182.5	11924	1149.3	8.08	5499	499.9	5.49
		22 x 2½	20½	602	177.0	11338	1106.1	8.00	5277	479.7	5.46
	8 x 6 x ⅞	22 x 2½	20½	581	170.9	11119	1084.8	8.07	5171	470.1	5.50
		22 x 2⅜	20¼	563	165.4	10549	1041.9	7.99	4949	449.9	5.47
		21 x 2⅜	20¼	547	160.7	10168	1004.2	7.96	4400	419.0	5.24
	8 x 4 x 1	20 x 2⅜	20¼	524	154.0	9937	981.4	8.03	4001	400.1	5.10
		20 x 2¼	20	507	149.0	9429	942.9	7.95	3834	383.4	5.07
		19 x 2¼	20	491	144.5	9073	907.3	7.92	3406	358.5	4.86
14 x 1	8 x 4 x 1	19 x 2¼	19	488	143.5	7999	842.0	7.46	3406	358.5	4.87
		18 x 2¼	19	473	139.0	7682	808.6	7.43	3021	335.7	4.66
14 x 1⅛	8 x 4 x ⅞	18 x 2¼	19	461	135.7	7533	792.9	7.45	2933	325.9	4.65
		18 x 2⅛	18¾	446	131.2	7132	760.8	7.37	2812	312.4	4.63
14 x ¾	8 x 4 x ⅞	17 x 2¼	19	428	125.9	7130	750.5	7.53	2536	298.4	4.49
	8 x 4 x ⅞	17 x 2	18½	399	117.4	6383	690.1	7.37	2332	274.4	4.46
	8 x 4 x ⅞	17 x 1¾	18	371	108.9	5675	630.6	7.22	2127	250.2	4.42
14 x 13/16	8 x 4 x ⅞	17 x 1⅝	17¾	359	105.6	5352	603.0	7.12	2033	239.2	4.39
		17 x 1½	17½	345	101.3	5022	573.9	7.04	1931	227.2	4.37
		17 x 1⅜	17¼	330	97.05	4701	545.0	6.95	1828	215.1	4.34
		17 x 1¼	17	316	92.80	4390	516.5	6.88	1726	203.1	4.31
		17 x 1⅛	16¾	301	88.55	4087	488.0	6.79	1623	190.9	4.28

Properties are given for gross section; properties of net section must be used if extreme fibers are in tension.
Weights given do not include rivet heads.

PLATE AND ANGLE COLUMNS

PROPERTIES OF SECTIONS

SHORT LEGS CONNECTED TO WEB PLATE



MATERIAL			Total Depth	Weight per Foot	Gross Area	AXIS X-X			AXIS Y-Y		
One Web Plate	Four Angles	Two Cover Plates				I	S	r	I	S	r
			In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.
14 x ¾	8 x 4 x ¾	16 x 1¼	17	287	84.26	4035	474.7	6.92	1447	180.9	4.14
	7 x 4 x ⅞	16 x 1	16½	265	77.94	3500	424.2	6.70	1158	144.8	3.86
	7 x 4 x ¾	16 x 1	16½	249	73.26	3335	404.2	6.75	1090	136.3	3.86
	7 x 4 x ¾	16 x ⅞	16¼	236	69.26	3067	377.5	6.65	1005	125.6	3.81
	7 x 4 x ¾	16 x 13/16	16⅛	229	67.26	2931	363.5	6.60	962	120.3	3.78
14 x 11/16	7 x 4 x ¾	16 x ¾	16	219	64.39	2788	348.5	6.58	914	114.3	3.77
	7 x 4 x ¾	16 x 11/16	15⅞	212	62.39	2661	335.2	6.53	871	108.9	3.74
14 x ⅝	7 x 4 x ¾	16 x ⅝	15¾	202	59.51	2521	320.1	6.51	823	102.9	3.72
14 x 9/16	7 x 4 x ¾	16 x 9/16	15⅝	192	56.64	2384	305.2	6.49	775	96.9	3.70
14 x ⅝	7 x 4 x ⅝	16 x ⅝	15¾	186	54.67	2347	298.0	6.55	756	94.5	3.72
14 x 9/16	7 x 4 x ⅝	16 x 9/16	15⅝	176	51.80	2210	282.9	6.53	709	88.6	3.70
14 x ½	7 x 4 x ⅝	16 x ½	15½	166	48.92	2072	267.4	6.51	661	82.6	3.68
	7 x 4 x ⅝	15 x 7/16	15⅜	157	46.05	1903	247.5	6.43	566	75.5	3.51
	7 x 4 x ⅝	15 x ⅜	15¼	150	44.17	1794	235.3	6.37	531	70.8	3.47
	7 x 4 x 9/16	15 x ⅜	15¼	142	41.73	1700	223.0	6.38	499	66.5	3.46
14 x ⅜	7 x 4 x ⅞	—	14½	139	40.69	1489	205.4	6.05	437	60.8	3.28
14 x ½	7 x 4 x ¾	—	14½	128	37.76	1348	185.9	5.98	386	53.2	3.20
14 x ⅜	7 x 4 x ¾	—	14½	123	36.01	1324	182.6	6.06	375	52.2	3.23
14 x ½	7 x 4 x ⅝	—	14½	112	32.92	1171	161.5	5.96	320	44.1	3.12
14 x ⅜	7 x 4 x 9/16	—	14½	104	30.48	1078	148.7	5.95	288	39.7	3.08
	7 x 4 x 9/16	—	14½	97.9	28.73	1049	144.7	6.04	280	39.0	3.12
	7 x 4 x ½	—	14½	89.5	26.25	953	131.4	6.03	249	34.6	3.08
	6 x 4 x ½	—	14½	82.7	24.25	856	118.1	5.94	160	25.9	2.57
	6 x 4 x 7/16	—	14½	75.1	21.97	770	106.2	5.92	139	22.5	2.52
	5x3½x ½	—	14½	72.3	21.25	745	102.8	5.92	94.7	18.3	2.11
	5x3½x 7/16	—	14½	65.9	19.37	673	92.8	5.89	82.3	15.9	2.06
	5x3½x ⅜	—	14½	59.5	17.45	597	82.3	5.85	70.6	13.6	2.01
	4 x 3 x 7/16	—	14½	57.1	16.73	572	78.9	5.85	43.6	10.4	1.61
	4 x 3 x ⅜	—	14½	51.9	15.17	509	70.2	5.79	37.3	8.9	1.57
14 x 5/16	4 x 3 x ⅜	—	14½	48.9	14.30	495	68.3	5.88	36.3	8.7	1.59
	4 x 3 x 5/16	—	14½	43.7	12.74	431	59.4	5.81	30.3	7.3	1.54
12 x ¾	6 x 4 x ¾	13 x ¾	14	191	56.26	1742	248.9	5.56	540	83.1	3.10
	6 x 4 x ⅝	13 x ¾	14	177	51.94	1634	233.4	5.61	495	76.2	3.09
12 x ⅝	6 x 4 x ⅝	13 x ⅝	13¾	161	47.20	1460	212.4	5.56	442	68.0	3.06
12 x 9/16	6 x 4 x ⅝	13 x ½	13½	147	43.19	1300	192.6	5.49	393	60.5	3.02

Properties are given for gross section; properties of net section must be used if extreme fibers are in tension.
Weights given do not include rivet heads.

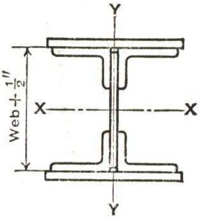
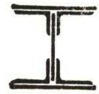


PLATE AND ANGLE COLUMNS



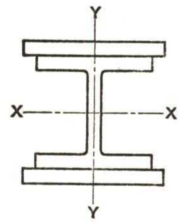
PROPERTIES OF SECTIONS

SHORT LEGS CONNECTED TO WEB PLATE

MATERIAL			Total Depth	Weight per Foot	Gross Area	AXIS X-X			AXIS Y-Y		
One Web Plate	Four Angles	Two Cover Plates				I	S	r	I	S	r
			In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.
12 x 1/2	6 x 4 x 5/8	13 x 3/8	13 1/4	134	39.20	1145	172.8	5.41	344	52.9	2.96
	6 x 4 x 9/16	13 x 5/16	13 1/8	120	35.36	1017	155.0	5.36	300	46.2	2.91
	6 x 4 x 5/8	—	12 1/2	100	29.44	741	118.6	5.02	206	33.0	2.65
	6 x 4 x 9/16	—	12 1/2	92.8	27.24	683	109.3	5.01	186	29.8	2.61
12 x 3/8	6 x 4 x 9/16	—	12 1/2	87.7	25.74	665	106.4	5.08	180	29.1	2.64
	6 x 4 x 1/2	—	12 1/2	80.1	23.50	605	96.8	5.07	160	25.9	2.61
	6 x 4 x 7/16	—	12 1/2	72.5	21.22	544	87.0	5.06	139	22.5	2.56
	6 x 4 x 3/8	—	12 1/2	64.5	18.94	481	77.0	5.04	119	19.2	2.51
	5x3 1/2x 7/16	—	12 1/2	63.3	18.62	476	76.2	5.06	82.3	15.9	2.10
12 x 5/16	5x3 1/2x 7/16	—	12 1/2	60.8	17.87	467	74.7	5.11	80.7	15.7	2.13
	5x3 1/2x 3/8	—	12 1/2	54.4	15.95	412	65.9	5.08	69.2	13.4	2.08
	4 x 3 x 7/16	—	12 1/2	52.0	15.23	395	63.2	5.09	42.4	10.2	1.67
	4 x 3 x 3/8	—	12 1/2	46.8	13.67	350	56.0	5.06	36.3	8.7	1.63
	4 x 3 x 5/16	—	12 1/2	41.6	12.11	304	48.6	5.01	30.3	7.3	1.58
10 x 1/2	5x3 1/2x 5/8	11 x 11/16	11 7/8	136	39.81	898	151.2	4.75	276	50.2	2.63
10 x 7/16	5x3 1/2x 5/8	11 x 9/16	11 5/8	124	36.43	798	137.3	4.68	245	44.5	2.59
	5x3 1/2x 1/2	11 x 9/16	11 5/8	111	32.75	734	126.3	4.73	221	40.2	2.60
10 x 3/8	5x3 1/2x 1/2	11 x 7/16	11 3/8	99.9	29.38	637	112.0	4.66	192	34.9	2.55
	5x3 1/2x 1/2	11 x 5/16	11 1/8	90.5	26.63	551	99.1	4.55	164	29.8	2.48
	5x3 1/2x 5/8	—	10 1/2	80.0	23.43	413	78.7	4.20	118	22.7	2.25
10 x 5/16	5x3 1/2x 1/2	—	10 1/2	65.0	19.13	344	65.5	4.24	92.7	18.0	2.20
	5x3 1/2x 7/16	—	10 1/2	58.6	17.25	310	59.0	4.24	80.7	15.7	2.16
10 x 1/4	5x3 1/2x 3/8	—	10 1/2	50.1	14.70	269	51.2	4.28	67.8	13.2	2.15
	4 x 3 x 7/16	—	10 1/2	47.7	13.98	257	49.0	4.28	41.4	10.0	1.72
	4 x 3 x 3/8	—	10 1/2	42.5	12.42	227	43.2	4.28	35.4	8.6	1.69
	4 x 3 x 5/16	—	10 1/2	37.3	10.86	196	37.3	4.25	29.6	7.2	1.65
	4 x 3 x 1/4	—	10 1/2	31.7	9.26	164	31.2	4.21	23.7	5.7	1.60
8 x 3/8	4 x 3 x 5/8	—	8 1/2	64.6	18.92	209	49.2	3.32	62.7	15.0	1.82
	4 x 3 x 1/2	—	8 1/2	54.6	16.00	178	41.9	3.34	50.1	12.0	1.77
8 x 5/16	4 x 3 x 7/16	—	8 1/2	47.7	13.98	158	37.2	3.37	42.4	10.2	1.74
	4 x 3 x 3/8	—	8 1/2	42.5	12.42	140	32.9	3.36	36.3	8.7	1.71
8 x 1/4	4 x 3 x 5/16	—	8 1/2	35.6	10.36	118	27.8	3.38	29.6	7.2	1.69
	4 x 3 x 1/4	—	8 1/2	30.0	8.76	99.7	23.5	3.37	23.7	5.7	1.65
	3x2 1/2x 5/16	—	8 1/2	29.2	8.48	91.2	21.5	3.28	12.9	4.1	1.23
	3x2 1/2x 1/4	—	8 1/2	24.8	7.24	76.5	18.0	3.25	10.3	3.3	1.19

Properties are given for gross section; properties of net section must be used if extreme fibers are in tension.
Weights given do not include rivet heads.

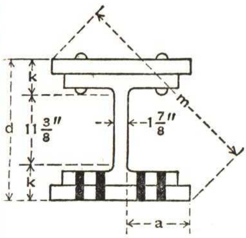
COVER PLATED
WF COLUMNS
PROPERTIES FOR DESIGNING



14 WF 320 CORE SECTION

COVER PLATES		Total Depth d	Total Weight per Foot	Total Area	AXIS X-X			AXIS Y-Y		
Width	Thickness				I	S	r	I	S	r
In.	In.	In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.
24	3⅝	24.06	912	268.1	22497	1870	9.16	9987	832	6.10
	3½	23.81	891	262.1	21638	1818	9.09	9699	808	6.08
	3⅜	23.56	871	256.1	20797	1765	9.01	9411	784	6.06
	3¼	23.31	850	250.1	19973	1714	8.94	9123	760	6.04
	3⅛	23.06	830	244.1	19166	1662	8.86	8835	736	6.02
	3	22.81	810	238.1	18377	1611	8.79	8547	712	5.99
23	3	22.81	789	232.1	17784	1559	8.75	7719	671	5.77
	2⅞	22.56	770	226.4	17044	1511	8.68	7465	649	5.74
	2¾	22.31	750	220.6	16321	1463	8.60	7212	627	5.72
22	2¾	22.31	731	215.1	15791	1416	8.57	6515	592	5.50
	2⅝	22.06	713	209.6	15115	1370	8.49	6294	572	5.48
	2½	21.81	694	204.1	14453	1325	8.41	6072	552	5.45
	2⅜	21.56	675	198.6	13806	1281	8.34	5850	532	5.43
	2¼	21.31	657	193.1	13175	1236	8.26	5628	512	5.40
	2⅛	21.06	638	187.6	12558	1193	8.18	5406	491	5.37
	2	20.81	619	182.1	11955	1149	8.10	5184	471	5.34
	1⅞	20.56	601	176.6	11367	1106	8.02	4963	451	5.30
	1¾	20.31	582	171.1	10792	1063	7.94	4741	431	5.26
	1⅝	20.06	563	165.6	10232	1020	7.86	4519	411	5.22
	1½	19.81	544	160.1	9686	978	7.78	4297	391	5.18
20	1½	19.81	524	154.1	9182	927	7.72	3635	364	4.86
	1⅜	19.56	507	149.1	8697	889	7.64	3468	347	4.82
	1¼	19.31	490	144.1	8225	852	7.55	3302	330	4.79
18	1¼	19.31	473	139.1	7817	810	7.50	2850	317	4.53
	1⅛	19.06	458	134.6	7403	777	7.42	2729	303	4.50
	1	18.81	442	130.1	6999	744	7.33	2607	290	4.48

Properties are given for gross section; properties of net section must be used if extreme fibers are in tension.
Weights given do not include rivet heads.
For properties and dimensions of 14 WF 320, see pages 18 and 19.



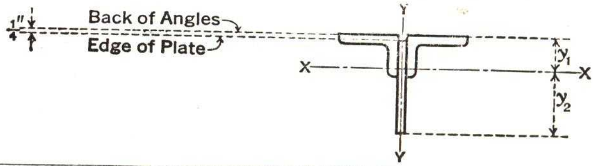
COVER PLATED
WF COLUMNS
DIMENSIONS FOR DETAILING

14 WF 320 CORE SECTION

COVER PLATES		DIMENSIONS						Usual Flange Gage
Width	Thickness	Total Depth d	Total Weight per Foot	Flange Thickness	Distance a	Distance k	Distance m	
In.	In.	In.	Lb.	In.	In.	In.	In.	In.
24	3 5/8	24	912	5 11/16	11	6 5/16	34	3-5½-3
	3 1/2	23 3/4	891	5 9/16	11	6 3/16	33 7/8	3-5½-3
	3 3/8	23 1/2	871	5 7/16	11	6 1/16	33 3/4	3-5½-3
	3 1/4	23 1/4	850	5 5/16	11	5 15/16	33 1/2	3-5½-3
	3 1/8	23	830	5 3/16	11	5 13/16	33 3/8	3-5½-3
	3	22 3/4	810	5 1/16	11	5 11/16	33 1/8	3-5½-3
23	3	22 3/4	789	5 1/16	10 1/2	5 11/16	32 1/2	3-5½-3
	2 7/8	22 1/2	770	4 15/16	10 1/2	5 9/16	32 1/4	3-5½-3
	2 3/4	22 1/4	750	4 13/16	10 1/2	5 7/16	32 1/8	3-5½-3
22	2 3/4	22 1/4	731	4 13/16	10	5 7/16	31 3/8	3-5½-3
	2 5/8	22	713	4 11/16	10	5 5/16	31 1/4	3-5½-3
	2 1/2	21 3/4	694	4 9/16	10	5 3/16	31	3-5½-3
	2 3/8	21 1/2	675	4 7/16	10	5 1/16	30 7/8	3-5½-3
	2 1/4	21 1/4	657	4 5/16	10	4 15/16	30 3/4	3-5½-3
	2 1/8	21	638	4 3/16	10	4 13/16	30 1/2	3-5½-3
	2	20 3/4	619	4 1/16	10	4 11/16	30 3/8	3-5½-3
	1 7/8	20 1/2	601	3 15/16	10	4 9/16	30 1/8	3-5½-3
	1 3/4	20 1/4	582	3 13/16	10	4 7/16	30	3-5½-3
	1 5/8	20	563	3 11/16	10	4 5/16	29 7/8	3-5½-3
	1 1/2	19 3/4	544	3 9/16	10	4 3/16	29 5/8	3-5½-3
20	1 1/2	19 3/4	524	3 9/16	9	4 3/16	28 1/4	3-5½-3
	1 3/8	19 1/2	507	3 7/16	9	4 1/16	28	3-5½-3
	1 1/4	19 1/4	490	3 5/16	9	3 15/16	27 7/8	3-5½-3
18	1 1/4	19 1/4	473	3 5/16	8	3 15/16	26 1/2	3-5½-3
	1 1/8	19	458	3 3/16	8	3 13/16	26 1/4	3-5½-3
	1	18 3/4	442	3 1/16	8	3 11/16	26 1/8	3-5½-3

Properties are given for gross section; properties of net section must be used if extreme fibers are in tension.
Weights given do not include rivet heads.
For properties and dimensions of 14 WF 320, see pages 18 and 19

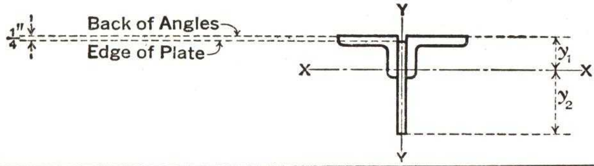
PROPERTIES OF TWO ANGLES AND ONE PLATE



Size Plate	Size Angles	Gross Area	Strut Area	Axis X-X: I	Axis X-X: $S_1=I/y_1$	Axis X-X: $S_2=I/y_2$	Axis X-X: r	Axis X-X: y_1	Axis Y-Y: r
In.	In.	In.^{2}	In.^{2}	In.^{4}	In.^{3}	In.^{3}	In.	In.	In.
14 x 3/8	8 x 4 x 1/2	16.75	14.59	246.2	86.1	21.6	3.83	2.86	3.31
	7 x 4 x 1/2	15.75	13.59	239.1	78.9	21.3	3.90	3.03	2.82
	6 x 4 x 1/2	14.75	12.59	230.9	71.7	20.9	3.96	3.22	2.33
	5 x 3½ x 1/2	13.25	10.91	221.2	64.7	20.4	4.09	3.42	1.89
	7 x 4 x 7/16	14.49	12.33	232.6	72.9	21.0	4.01	3.19	2.74
	6 x 4 x 7/16	13.61	11.45	224.7	66.3	20.7	4.06	3.39	2.26
	5 x 3½ x 7/16	12.31	9.97	215.3	59.8	20.2	4.18	3.60	1.83
	7 x 4 x 3/8	13.21	11.05	225.0	66.0	20.8	4.13	3.41	2.66
	6 x 4 x 3/8	12.47	10.31	216.7	60.2	20.4	4.17	3.60	2.19
	5 x 3½ x 3/8	11.35	9.01	207.5	54.3	19.9	4.28	3.82	1.77
12 x 1/2	6 x 4 x 9/16	16.62	15.74	191.0	65.9	20.4	3.39	2.90	2.36
	5 x 3½ x 9/16	14.94	13.81	182.7	59.5	19.9	3.50	3.07	1.93
	4 x 3 x 9/16	13.24	11.99	173.1	52.5	19.3	3.62	3.30	1.50
	6 x 4 x 1/2	15.50	14.62	186.5	61.5	20.2	3.47	3.03	2.31
	5 x 3½ x 1/2	14.00	12.87	177.9	55.6	19.7	3.57	3.20	1.88
	4 x 3 x 1/2	12.50	11.25	168.4	49.1	19.1	3.67	3.43	1.46
	6 x 4 x 7/16	14.36	13.48	180.9	57.1	19.9	3.55	3.17	2.24
	5 x 3½ x 7/16	13.06	11.93	172.9	51.6	19.4	3.64	3.35	1.81
	4 x 3 x 7/16	11.74	10.49	163.6	45.5	19.0	3.74	3.60	1.40
12 x 7/16	6 x 4 x 1/2	14.75	13.55	169.0	59.1	18.0	3.39	2.86	2.35
	5 x 3½ x 1/2	13.25	11.83	161.7	53.4	17.5	3.49	3.03	1.91
	4 x 3 x 1/2	11.75	10.22	153.1	47.1	17.0	3.61	3.25	1.48
	6 x 4 x 7/16	13.61	12.41	164.4	54.8	17.8	3.48	3.00	2.28
	5 x 3½ x 7/16	12.31	10.89	157.1	49.6	17.3	3.57	3.17	1.85
	4 x 3 x 7/16	10.99	9.46	148.7	43.7	16.8	3.68	3.40	1.43
	6 x 4 x 3/8	12.47	11.27	158.7	49.9	17.5	3.57	3.18	2.20
	5 x 3½ x 3/8	11.35	9.93	151.2	45.1	17.0	3.65	3.35	1.78
	4 x 3 x 3/8	10.21	8.68	143.1	39.9	16.5	3.74	3.59	1.37
12 x 3/8	6 x 4 x 7/16	12.86	11.45	147.0	52.3	15.6	3.38	2.81	2.33
	5 x 3½ x 7/16	11.56	9.97	140.5	47.3	15.1	3.49	2.97	1.89
	4 x 3 x 7/16	10.24	8.55	133.4	41.7	14.7	3.61	3.20	1.46
	6 x 4 x 3/8	11.72	10.31	142.0	47.7	15.3	3.48	2.98	2.26
	5 x 3½ x 3/8	10.60	9.01	135.7	43.1	14.9	3.58	3.15	1.83
	4 x 3 x 3/8	9.46	7.77	128.4	38.0	14.5	3.68	3.38	1.40
	3½ x 3 x 3/8	9.10	7.41	124.5	35.4	14.3	3.70	3.52	1.19
	5 x 3½ x 5/16	9.62	8.03	129.5	38.4	14.6	3.67	3.37	1.75
	4 x 3 x 5/16	8.68	6.99	122.7	34.0	14.2	3.76	3.61	1.34
	3½ x 3 x 5/16	8.36	6.67	118.7	31.7	13.9	3.77	3.74	1.13
12 x 5/16	5 x 3½ x 3/8	9.85	8.21	118.8	40.8	12.7	3.47	2.91	1.87
	4 x 3 x 3/8	8.71	6.99	112.9	36.0	12.4	3.60	3.14	1.45
	3½ x 3 x 3/8	8.35	6.63	109.4	33.5	12.2	3.62	3.27	1.22
	5 x 3½ x 5/16	8.87	7.23	113.4	36.1	12.4	3.57	3.14	1.81
	4 x 3 x 5/16	7.93	6.21	108.0	32.1	12.2	3.69	3.36	1.39
	3½ x 3 x 5/16	7.61	5.89	104.4	29.9	12.0	3.71	3.50	1.17
	3 x 2½ x 5/16	6.99	5.15	100.8	27.5	11.7	3.80	3.67	0.98

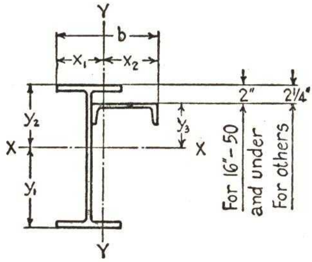
Note: "Strut Area" is that remaining after deduction (A. I. S. C. Spec. Sect. 18 (c)) of plate width (as measured from free edge to center of rivet) in excess of 16 times thickness; and therefore available in resistance to compression.

PROPERTIES OF TWO ANGLES AND ONE PLATE



Size Plate	Size Angles	Gross Area	Strut Area	AXIS X-X I	AXIS X-X $S_1 = I/y_1$	AXIS X-X $S_2 = I/y_2$	AXIS X-X r	AXIS X-X y_1	AXIS Y-Y r
In.	In.	In.^{2}	In.^{2}	In.^{4}	In.^{3}	In.^{3}	In.	In.	In.
12 x 5/16	4 x 3 x ¼	7.13	5.41	101.7	28.0	11.8	3.78	3.64	1.31
	3½ x 3 x ¼	6.87	5.15	98.4	26.1	11.6	3.78	3.77	1.10
	3 x 2½ x ¼	6.37	4.53	94.7	24.0	11.4	3.86	3.95	0.92
10 x ⅜	5 x 3½ x ⅜	9.85	9.01	82.3	32.5	10.7	2.89	2.53	1.89
	4 x 3 x ⅜	8.71	7.77	77.7	28.8	10.3	2.99	2.70	1.46
	3½ x 3 x ⅜	8.35	7.41	75.5	26.8	10.2	3.01	2.82	1.24
	5 x 3½ x 5/16	8.87	8.03	78.7	29.1	10.4	2.98	2.70	1.82
	4 x 3 x 5/16	7.93	6.99	74.4	25.8	10.1	3.06	2.88	1.40
	3½ x 3 x 5/16	7.61	6.67	72.0	24.0	9.9	3.07	3.00	1.19
	3 x 2½ x 5/16	6.99	5.91	69.2	22.2	9.7	3.15	3.13	0.99
10 x 5/16	5 x 3½ x ⅜	9.23	8.21	72.3	30.8	9.2	2.80	2.35	1.94
	4 x 3 x ⅜	8.09	6.99	68.2	27.2	8.8	2.91	2.51	1.50
	3½ x 3 x ⅜	7.72	6.63	66.1	25.2	8.7	2.93	2.62	1.27
	3 x 2½ x ⅜	6.97	5.75	63.7	23.2	8.5	3.02	2.75	1.08
	5 x 3½ x 5/16	8.25	7.23	69.2	27.6	8.9	2.90	2.51	1.87
	4 x 3 x 5/16	7.30	6.21	65.4	24.4	8.6	2.99	2.68	1.45
	3½ x 3 x 5/16	6.99	5.89	63.3	22.6	8.5	3.01	2.80	1.22
	3 x 2½ x 5/16	6.36	5.15	61.0	20.9	8.3	3.10	2.92	1.02
	4 x 3 x ¼	6.50	5.41	61.8	21.3	8.4	3.08	2.91	1.37
	3½ x 3 x ¼	6.25	5.15	59.6	19.8	8.2	3.09	3.02	1.16
	3 x 2½ x ¼	5.74	4.53	57.5	18.3	8.1	3.16	3.15	0.96
10 x ¼	4 x 3 x ¼	5.88	4.75	52.8	19.9	7.0	3.00	2.66	1.42
	3½ x 3 x ¼	5.62	4.49	51.0	18.4	6.8	3.01	2.77	1.20
	3 x 2½ x ¼	5.12	3.90	49.3	17.0	6.7	3.10	2.90	1.01
9 x 5/16	5 x 3½ x 5/16	7.93	7.23	52.3	23.4	7.4	2.57	2.23	1.91
	4 x 3 x 5/16	6.99	6.21	49.0	20.8	7.1	2.65	2.36	1.48
	3½ x 3 x 5/16	6.67	5.89	47.5	19.2	7.0	2.67	2.47	1.24
	3 x 2½ x 5/16	6.05	5.15	45.7	17.8	6.8	2.75	2.57	1.05
	4 x 3 x ¼	6.19	5.41	46.4	18.1	6.9	2.73	2.56	1.40
	3½ x 3 x ¼	5.93	5.15	44.8	16.8	6.8	2.75	2.67	1.18
	3 x 2½ x ¼	5.43	4.53	43.2	15.5	6.7	2.82	2.78	0.99
9 x ¼	4 x 3 x ¼	5.63	4.75	39.6	16.9	5.7	2.65	2.34	1.42
	3½ x 3 x ¼	5.37	4.49	38.3	15.6	5.6	2.67	2.45	1.22
	3 x 2½ x ¼	4.87	3.90	36.9	14.5	5.5	2.75	2.55	1.03
8 x 5/16	4 x 3 x 5/16	6.68	6.21	35.7	17.3	5.8	2.31	2.07	1.51
	3½ x 3 x 5/16	6.36	5.89	34.4	15.9	5.7	2.33	2.16	1.27
	3 x 2½ x 5/16	5.74	5.15	33.1	14.8	5.5	2.40	2.23	1.08
	4 x 3 x ¼	5.88	5.41	33.7	15.1	5.6	2.39	2.23	1.44
	3½ x 3 x ¼	5.62	5.15	32.5	14.0	5.5	2.40	2.33	1.21
	3 x 2½ x ¼	5.12	4.53	31.3	13.0	5.4	2.47	2.41	1.02
8 x ¼	4 x 3 x ¼	5.38	4.75	28.9	14.1	4.7	2.32	2.05	1.48
	3½ x 3 x ¼	5.12	4.49	27.9	13.0	4.6	2.33	2.44	1.25
	3 x 2½ x ¼	4.62	3.90	26.7	12.1	4.4	2.41	2.21	1.06
7 x ¼	3½ x 3 x ¼	4.87	4.49	19.5	10.5	3.6	2.00	1.85	1.28
	3 x 2½ x ¼	4.37	3.90	18.7	9.8	3.5	2.07	1.90	1.09

Note: "Strut Area" is that remaining after deduction (A. I. S. C. Spec. Sect. 18 (c)) of plate width (as measured from free edge to center of rivet) in excess of 16 times thickness; and therefore available in resistance to compression.



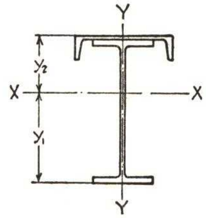
WIDE FLANGE BEAMS AND CHANNELS

PROPERTIES OF SECTIONS

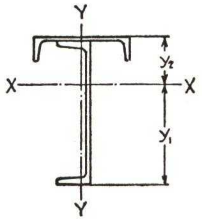
Size and Weight		Total Weight	Total Area	AXIS X-X					AXIS Y-Y				
				$S_1=\frac{I}{y_1}$	$S_2=\frac{I}{y_2}$	$S_3=\frac{I}{y_3}$	r	y_1	$S_1=\frac{I}{x_1}$	$S_2=\frac{I}{x_2}$	r	x_1	b
Beam	Channel	Lb.	In.²	In.³	In.³	In.³	In.	In.	In.³	In.³	In.	In.	In.
10" — 21	8"—11.5	32.5	9.55	20.7	29.1	56.5	3.54	5.78	18.2	11.8	2.88	4.33	11.00
25	11.5	36.5	10.71	25.6	34.8	65.4	3.72	5.81	20.2	12.3	2.80	4.18	11.01
29	11.5	40.5	11.89	29.9	39.6	72.5	3.83	5.82	21.8	12.8	2.73	4.07	11.04
12" — 27	8"—11.5	38.5	11.33	33.3	46.8	78.4	4.53	6.99	19.9	12.9	2.80	4.47	11.37
31	11.5	42.5	12.48	38.6	52.7	86.5	4.64	6.98	21.5	13.4	2.74	4.38	11.40
36	11.5	47.5	13.95	45.1	59.6	96.0	4.74	6.97	23.3	14.0	2.68	4.28	11.44
14" — 30	8"—11.5	41.5	12.17	41.4	58.8	90.3	5.26	8.13	20.3	13.0	2.74	4.51	11.51
34	11.5	45.5	13.36	48.0	66.2	100.2	5.40	8.11	21.9	13.6	2.69	4.42	11.52
38	11.5	49.5	14.53	54.1	72.8	109.0	5.49	8.10	23.3	14.1	2.64	4.35	11.55
16" — 36	8"—11.5	47.5	13.95	56.5	78.5	112.4	6.11	9.21	21.9	13.8	2.66	4.50	11.65
40	11.5	51.5	15.13	64.5	87.3	123.7	6.26	9.20	23.5	14.4	2.62	4.42	11.65
40	10"—15.3	55.3	16.24	64.4	93.7	135.1	6.13	9.48	36.5	20.6	3.32	4.92	13.65
16" — 45	8"—11.5	56.5	16.60	72.5	95.7	134.4	6.33	9.17	25.0	14.9	2.56	4.36	11.69
45	10"—15.3	60.3	17.71	72.5	102.2	145.8	6.21	9.43	38.7	21.0	3.24	4.82	13.69
50	8"—11.5	61.5	18.06	80.9	104.5	145.5	6.40	9.15	26.7	15.5	2.52	4.32	11.73
50	10"—15.3	65.3	19.17	80.9	111.2	157.2	6.30	9.40	40.8	21.6	3.18	4.75	13.73
18" — 50	8"—11.5	61.5	18.07	89.3	115.4	161.8	7.08	10.15	25.9	15.8	2.55	4.53	11.93
50	10"—15.3	65.3	19.18	89.3	122.8	174.6	6.97	10.42	39.6	21.9	3.20	4.96	13.93
55	8"—11.5	66.5	19.55	98.6	125.1	174.1	7.15	10.13	27.4	16.5	2.51	4.49	11.97
55	10"—15.3	70.3	20.66	98.7	132.7	187.2	7.05	10.39	41.6	22.4	3.14	4.89	13.97
18" — 60	8"—11.5	71.5	21.00	108.3	135.1	187.0	7.23	10.13	29.1	17.2	2.48	4.45	11.99
60	10"—15.3	75.3	22.11	108.3	143.0	200.4	7.13	10.39	43.6	23.0	3.09	4.83	13.99
64	8"—11.5	75.5	22.16	116.9	144.0	200.3	7.21	9.87	30.6	20.3	2.63	5.00	12.56
64	10"—15.3	79.3	23.27	116.9	151.7	213.4	7.12	10.10	43.8	25.5	3.18	5.36	14.56
21" — 62	8"—11.5	73.5	21.59	127.9	160.7	212.0	8.32	11.69	28.4	17.9	2.50	4.77	12.32
62	10"—15.3	77.3	22.70	128.1	170.8	227.8	8.23	11.99	42.2	23.7	3.09	5.14	14.32
62	12"—20.7	82.7	24.26	128.4	184.3	249.4	8.10	12.37	62.8	33.3	3.83	5.66	16.32
68	10"—15.3	83.3	24.49	141.8	185.1	245.4	8.32	11.96	44.5	24.4	3.04	5.09	14.36
68	12"—20.7	88.7	26.05	142.1	198.9	267.3	8.20	12.32	65.9	34.1	3.76	5.58	16.36
73	10"—15.3	88.3	25.93	152.6	196.3	259.0	8.39	11.95	46.4	25.1	3.00	5.05	14.38
73	12"—20.7	93.7	27.49	153.0	210.4	281.2	8.27	12.30	68.4	34.8	3.71	5.52	16.38
24" — 76	10"—15.3	91.3	26.84	178.6	230.2	293.5	9.47	13.47	45.7	26.2	3.02	5.36	14.71
76	12"—20.7	96.7	28.40	179.2	247.5	318.9	9.36	13.87	66.8	35.6	3.70	5.81	16.71
84	10"—15.3	99.3	29.18	199.6	252.2	319.8	9.59	13.45	48.8	27.4	2.98	5.31	14.74
84	12"—20.7	104.7	30.74	200.2	269.9	345.7	9.49	13.83	70.6	36.8	3.63	5.73	16.74
94	10"—15.3	109.3	32.10	224.5	277.8	350.5	9.69	13.43	52.3	28.9	2.93	5.26	14.79
94	12"—20.7	114.7	33.66	225.2	296.0	376.8	9.60	13.79	75.0	33.1	3.55	5.65	16.79
94	15"—33.9	127.9	37.53	226.6	338.3	439.9	9.37	14.54	129.8	64.7	4.77	6.58	19.79
27"— 94	12"—20.7	114.7	33.68	248.9	329.8	409.4	10.65	15.34	71.4	39.2	3.60	6.11	17.24
94	15"—33.9	127.9	37.56	251.0	379.7	480.6	10.41	16.20	122.9	65.5	4.80	7.04	20.24
102	12"—20.7	122.7	36.04	272.5	354.5	438.4	10.76	15.31	75.0	40.5	3.55	6.06	17.27
102	15"—33.9	135.9	39.91	274.6	405.4	510.5	10.54	16.14	128.4	66.8	4.72	6.93	20.27
114	12"—20.7	134.7	39.56	305.7	388.7	478.3	10.86	15.27	80.0	42.4	3.48	6.00	17.32
114	15"—33.9	147.9	43.43	308.0	440.9	551.5	10.67	16.06	135.7	68.4	4.61	6.81	20.32

WIDE FLANGE BEAMS AND CHANNELS

PROPERTIES OF SECTIONS



Size and Weight		Total Weight	Total Area	AXIS X-X					AXIS Y-Y		
				I	$S_1=\frac{I}{y_1}$	$S_2=\frac{I}{y_2}$	r	y_1	I	S	r
Beam	Channel	Lb.	In.²	In.⁴	In.³	In.³	In.	In.	In.⁴	In.³	In.
8″— 17	8″—11.5	28.5	8.36	84.4	15.4	30.6	3.18	5.46	39.0	9.8	2.16
	10″—15.3	32.3	9.47	89.3	15.7	35.2	3.07	5.70	73.6	14.7	2.79
10″— 21	8″—11.5	32.5	9.55	153.6	23.4	43.1	4.01	6.56	42.0	10.5	2.10
	10″—15.3	36.3	10.66	162.3	23.7	49.5	3.90	6.86	76.6	15.3	2.68
12″— 27	10″—15.3	42.3	12.44	295.6	37.0	70.1	4.87	7.99	83.5	16.7	2.59
	12″—20.7	47.7	14.00	314.1	37.5	81.3	4.74	8.37	144.7	24.1	3.22
14″— 30	10″—15.3	45.3	13.28	418.3	45.8	84.2	5.61	9.13	84.4	16.9	2.52
	12″—20.7	50.7	14.84	445.0	46.5	97.6	5.48	9.58	145.6	24.3	3.13
16″— 36	12″—20.7	56.7	16.62	666.4	62.6	121.6	6.33	10.64	150.2	25.0	3.01
	15″—33.9	69.9	20.49	744.5	64.4	159.1	6.03	11.56	334.7	46.6	4.04
18″— 50	12″—20.7	70.7	20.74	1119.3	97.4	165.0	7.35	11.49	165.3	27.6	2.82
	15″—33.9	83.9	24.61	1247.5	100.1	210.2	7.12	12.46	349.8	46.6	3.77
21″— 62	12″—20.7	82.7	24.26	1790.6	137.7	216.5	8.59	13.00	181.2	30.2	2.73
	15″—33.9	95.9	28.13	1990.1	141.6	271.2	8.41	14.05	365.7	48.8	3.61
68	12″—20.7	88.7	26.05	1959.2	151.7	230.6	8.67	12.91	188.5	31.4	2.69
	15″—33.9	101.9	29.92	2172.3	155.9	285.9	8.52	13.93	373.0	49.7	3.53
24″— 76	12″—20.7	96.7	28.40	2732.3	189.7	279.2	9.81	14.40	204.6	34.1	2.68
	15″—33.9	109.9	32.27	3022.5	195.0	343.2	9.68	15.50	389.1	51.9	3.47
84	12″—20.7	104.7	30.74	3023.2	211.0	301.0	9.92	14.33	216.4	36.1	2.65
	15″—33.9	117.9	34.61	3332.6	216.7	365.8	9.81	15.38	400.9	53.5	3.40
27″— 94	12″—20.7	114.7	33.68	4111.7	260.4	360.6	11.05	15.79	243.2	40.5	2.69
	15″—33.9	127.9	37.55	4519.2	267.4	434.1	10.97	16.90	427.7	57.0	3.37
102	12″—20.7	122.7	36.04	4471.7	284.3	384.8	11.14	15.73	257.6	42.9	2.67
	15″—33.9	135.9	39.91	4898.6	291.7	458.9	11.08	16.80	442.1	58.9	3.33
114	12″—20.7	134.7	39.56	4977.3	317.8	418.3	11.22	15.66	277.7	46.3	2.65
	15″—33.9	147.9	43.43	5430.7	326.0	492.8	11.18	16.66	462.2	61.6	3.26
30″—108	15″—33.9	141.9	41.67	6060.5	330.1	511.0	12.06	18.36	447.7	59.7	3.28
	18″—42.7	150.7	44.25	6349.2	334.3	562.9	11.98	18.99	684.1	76.0	3.93
116	15″—33.9	149.9	44.03	6564.6	358.9	542.1	12.21	18.29	465.8	62.2	3.25
	18″—42.7	158.7	46.61	6867.9	363.4	594.6	12.14	18.90	702.2	78.0	3.88
124	15″—33.9	157.9	46.35	7035.0	386.1	570.1	12.32	18.22	482.3	64.3	3.23
	18″—42.7	166.7	48.93	7352.2	390.9	623.1	12.26	18.81	718.7	79.9	3.83
132	15″—33.9	165.9	48.73	7479.7	412.1	596.0	12.39	18.15	497.6	66.4	3.20
	18″—42.7	174.7	51.31	7808.2	416.9	649.6	12.34	18.73	734.0	81.6	3.78
33″—130	15″—33.9	163.9	48.16	8761.1	440.9	642.9	13.49	19.87	514.0	68.5	3.27
	18″—42.7	172.7	50.74	9153.3	446.3	701.9	13.44	20.51	750.6	83.4	3.85
141	15″—33.9	174.9	51.41	9566.9	483.4	686.8	13.64	19.79	542.3	72.3	3.25
	18″—42.7	183.7	53.99	9977.9	488.9	746.8	13.59	20.41	778.7	86.5	3.80
152	15″—33.9	185.9	54.61	10324.5	523.6	728.1	13.75	19.72	568.7	75.8	3.23
	18″—42.7	194.7	57.19	10754.2	529.5	788.4	13.71	20.31	805.1	89.5	3.71
36″—150	15″—33.9	183.9	54.06	11505.5	544.5	761.5	14.59	21.13	563.0	75.1	3.23
	18″—42.7	192.7	56.64	11996.7	551.1	826.2	14.55	21.77	799.4	88.8	3.76
160	15″—33.9	193.9	56.99	12283.7	583.3	800.8	14.68	21.06	588.0	78.4	3.21
	18″—42.7	202.7	59.57	12791.6	590.0	866.1	14.65	21.68	824.4	91.6	3.72
170	15″—33.9	203.9	59.88	13064.9	622.1	839.6	14.77	21.00	613.2	81.8	3.20
	18″—42.7	212.7	62.46	13589.5	629.1	905.4	14.75	21.60	849.6	94.4	3.69
182	15″—33.9	215.9	63.44	13928.5	665.5	882.1	14.82	20.93	640.3	85.4	3.18
	18″—42.7	224.7	66.02	14470.3	672.7	948.3	14.80	21.51	876.7	97.4	3.64
194	15″—33.9	227.9	67.01	14799.5	708.8	925.0	14.86	20.88	668.0	89.1	3.16
	18″—42.7	236.7	69.59	15359.9	716.8	991.0	14.86	21.43	904.4	100.5	3.61



TWO CHANNELS

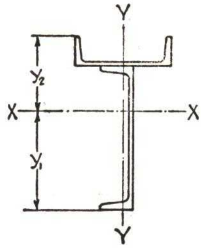
PROPERTIES OF SECTIONS

Vertical Channel Size and Weight	Horizontal Channel Size and Weight	Total Area	Weight per Foot	AXIS X-X					AXIS Y-Y		
				I	$S_1=\frac{I}{y_1}$	$S_2=\frac{I}{y_2}$	r	y_1	I	S	r
		In.²	Lb.	In.⁴	In.³	In.³	In.	In.	In.⁴	In.³	In.
3″— 4.1	4″— 5.4	2.75	9.5	2.9	1.3	3.0	1.03	2.19	4.0	2.0	1.21
4″— 5.4	4″— 5.4	3.12	10.8	6.4	2.2	4.9	1.44	2.86	4.1	2.1	1.15
	5″— 6.7	3.51	12.1	6.8	2.3	5.4	1.39	2.94	7.7	3.1	1.48
5″— 6.7	5″— 6.7	3.90	13.4	12.6	3.5	7.9	1.80	3.60	7.9	3.2	1.42
	6″— 8.2	4.34	14.9	13.2	3.6	8.8	1.74	3.70	13.5	4.5	1.76
	7″— 9.8	4.80	16.5	13.8	3.7	9.6	1.69	3.78	21.6	6.8	2.12
6″— 8.2	5″— 6.7	4.34	14.9	21.3	5.1	10.8	2.22	4.21	8.1	3.2	1.37
	6″— 8.2	4.78	16.4	22.3	5.1	12.0	2.16	4.34	13.7	4.6	1.69
	7″— 9.8	5.24	18.0	23.2	5.2	13.2	2.10	4.45	21.8	6.2	2.04
	8″—11.5	5.75	19.7	24.0	5.3	14.3	2.04	4.54	33.0	8.2	2.40
	9″—13.4	6.28	21.6	25.0	5.4	15.5	1.99	4.62	48.0	10.7	2.76
	10″—15.3	6.86	23.5	25.8	5.5	16.7	1.94	4.69	67.6	13.5	3.14
7″— 9.8	6″— 8.2	5.24	18.0	35.0	7.1	15.5	2.58	4.95	14.0	4.7	1.69
	7″— 9.8	5.70	19.6	36.3	7.2	17.0	2.52	5.08	22.1	6.3	1.97
	8″—11.5	6.21	21.3	37.6	7.2	18.6	2.46	5.20	33.3	8.3	2.31
	9″—13.4	6.74	23.2	38.9	7.4	20.2	2.40	5.30	48.3	10.7	2.68
	10″—15.3	7.32	25.1	40.2	7.4	21.7	2.34	5.39	67.9	13.6	3.05
8″—11.5	6″— 8.2	5.75	19.7	51.9	9.4	19.4	3.00	5.53	14.3	4.8	1.58
	7″— 9.8	6.21	21.3	53.9	9.5	21.3	2.95	5.68	22.4	6.4	1.90
	8″—11.5	6.72	23.0	55.9	9.6	23.3	2.88	5.82	33.6	8.4	2.24
	9″—13.4	7.25	24.9	57.8	9.7	25.2	2.82	5.94	48.6	10.8	2.59
	10″—15.3	7.83	26.8	59.5	9.8	27.2	2.76	6.05	68.2	13.6	2.95
	12″—20.7	9.39	32.2	63.8	10.1	32.2	2.61	6.30	129.4	21.6	3.71
9″—13.4	7″— 9.8	6.74	23.2	76.8	12.3	26.0	3.37	6.26	22.9	6.5	1.84
	8″—11.5	7.25	24.9	79.5	12.4	28.4	3.31	6.42	34.1	8.5	2.17
	9″—13.4	7.78	26.8	82.1	12.5	30.8	3.25	6.56	49.1	10.9	2.51
	10″—15.3	8.36	28.7	84.6	12.6	33.2	3.18	6.69	68.7	13.7	2.87
	12″—20.7	9.92	34.1	90.6	13.0	39.4	3.02	6.98	129.9	21.6	3.62
10″—15.3	8″—11.5	7.83	26.8	109.5	15.7	33.9	3.74	6.99	34.6	8.6	2.10
	9″—13.4	8.36	28.7	113.1	15.8	36.7	3.68	7.15	49.6	11.0	2.44
	10″—15.3	8.94	30.6	116.5	16.0	39.6	3.61	7.30	69.2	13.8	2.78
	12″—20.7	10.50	36.0	124.7	16.3	47.0	3.45	7.63	130.4	21.7	3.41
	15″—33.9	14.37	49.2	140.4	17.2	63.2	3.13	8.18	314.9	42.0	4.68
12″—20.7	9″—13.4	9.92	34.1	204.7	25.0	50.8	4.54	8.20	51.2	11.4	2.27
	10″—15.3	10.50	36.0	211.0	25.2	54.7	4.48	8.38	70.8	14.2	2.60
	12″—20.7	12.06	41.4	225.9	25.7	64.7	4.33	8.79	132.0	22.0	3.31
	15″—33.9	15.93	54.6	254.0	26.8	87.3	3.99	9.49	316.5	42.2	4.46
15″—33.9	10″—15.3	14.37	49.2	470.1	48.4	85.0	5.72	9.71	75.1	15.0	2.29
	12″—20.7	15.93	54.6	504.3	49.5	98.9	5.63	10.18	136.3	22.7	2.93
	15″—33.9	19.80	67.8	570.7	51.6	131.5	5.37	11.06	320.8	42.8	4.02
	18″—42.7	22.38	76.6	602.1	52.7	149.8	5.19	11.43	557.2	61.9	4.99
18″—42.7	12″—20.7	18.51	63.4	852.0	72.2	131.5	6.78	11.80	143.1	23.8	2.78
	15″—33.9	22.38	76.6	966.4	75.4	172.9	6.57	12.81	327.6	43.7	3.83
	18″—42.7	24.96	85.4	1020.7	76.9	197.0	6.39	13.27	564.0	62.7	4.75

Centers of gravity of both channels are in the same vertical line.

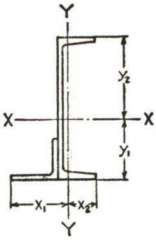
TWO CHANNELS

PROPERTIES OF SECTIONS



Vertical Channel Size and Weight	Horizontal Channel Size and Weight	Total Area	Weight per Foot	AXIS X-X					AXIS Y-Y		
				I	$S_1=\frac{I}{y_1}$	$S_2=\frac{I}{y_2}$	r	y_1	I	S	r
		In.^{2}	Lb.	In.^{4}	In.^{3}	In.^{3}	In.	In.	In.^{4}	In.^{3}	In.
3″— 4.1	4″— 5.4	2.75	9.5	4.5	1.7	2.3	1.28	2.61	4.0	2.0	1.21
4″— 5.4	4″— 5.4	3.12	10.8	8.8	2.7	3.8	1.69	3.23	4.1	2.1	1.15
	5″— 6.7	3.51	12.1	9.7	2.9	4.1	1.66	3.38	7.7	3.1	1.48
5″— 6.7	5″— 6.7	3.90	13.4	16.6	4.2	6.0	2.06	3.99	7.9	3.2	1.42
	6″— 8.2	4.34	14.9	17.9	4.3	6.5	2.03	4.16	13.5	4.5	1.76
	7″— 9.8	4.80	16.5	19.1	4.4	6.9	1.99	4.31	21.6	6.2	2.12
6″— 8.2	5″— 6.7	4.34	14.9	26.6	5.8	8.4	2.47	4.57	8.1	3.2	1.37
	6″— 8.2	4.78	16.4	28.5	6.0	9.0	2.44	4.76	13.7	4.6	1.69
	7″— 9.8	5.24	18.0	30.4	6.2	9.6	2.41	4.93	21.8	6.2	2.04
	8″—11.5	5.75	19.7	32.2	6.3	10.2	2.37	5.09	33.0	8.2	2.40
	9″—13.4	6.28	21.6	34.0	6.5	10.7	2.33	5.24	48.0	10.7	2.76
	10″—15.3	6.86	23.5	36.0	6.7	11.1	2.29	5.37	67.6	13.5	3.14
7″— 9.8	6″— 8.2	5.24	18.0	42.8	8.0	11.9	2.86	5.33	14.0	4.7	1.69
	7″— 9.8	5.70	19.6	45.5	8.2	12.8	2.82	5.52	22.1	6.3	1.97
	8″—11.5	6.21	21.3	48.0	8.4	13.5	2.78	5.71	33.3	8.3	2.31
	9″—13.4	6.74	23.2	50.7	8.6	14.2	2.74	5.87	48.3	10.7	2.68
	10″—15.3	7.32	25.1	53.2	8.8	14.9	2.70	6.03	67.9	13.6	3.05
8″—11.5	6″— 8.2	5.75	19.7	61.5	10.5	15.2	3.27	5.88	14.3	4.8	1.58
	7″— 9.8	6.21	21.3	65.2	10.7	16.3	3.24	6.09	22.4	6.4	1.90
	8″—11.5	6.72	23.0	68.8	10.9	17.3	3.20	6.29	33.6	8.4	2.24
	9″—13.4	7.25	24.9	72.5	11.2	18.3	3.16	6.47	48.6	10.8	2.59
	10″—15.3	7.83	26.8	75.9	11.4	19.2	3.11	6.65	68.2	13.6	2.95
	12″—20.7	9.39	32.2	83.8	11.9	21.4	2.99	7.02	129.4	21.6	3.71
9″—13.4	7″— 9.8	6.74	23.2	90.2	13.6	20.3	3.66	6.64	22.9	6.5	1.84
	8″—11.5	7.25	24.9	95.2	13.9	21.6	3.62	6.85	34.1	8.5	2.17
	9″—13.4	7.78	26.8	99.8	14.1	22.8	3.58	7.06	49.1	10.9	2.51
	10″—15.3	8.36	28.7	104.5	14.4	24.0	3.54	7.25	68.7	13.7	2.87
	12″—20.7	9.92	34.1	115.2	15.0	26.9	3.41	7.66	129.9	21.6	3.62
10″—15.3	8″—11.5	7.83	26.8	127.8	17.3	26.3	4.04	7.40	34.6	8.6	2.10
	9″—13.4	8.36	28.7	134.2	17.6	27.8	4.01	7.61	49.6	11.0	2.44
	10″—15.3	8.94	30.6	140.3	17.9	29.4	3.96	7.82	69.2	13.8	2.78
	12″—20.7	10.50	36.0	154.3	18.7	33.0	3.83	8.27	130.4	21.7	3.52
	15″—33.9	14.37	49.2	178.3	19.8	40.4	3.52	8.99	314.9	42.0	4.68
12″—20.7	9″—13.4	9.92	34.1	233.2	27.2	39.9	4.85	8.59	51.2	11.4	2.27
	10″—15.3	10.50	36.0	243.5	27.6	42.2	4.82	8.83	70.8	14.2	2.60
	12″—20.7	12.06	41.4	267.3	28.6	47.8	4.71	9.35	132.0	22.0	3.31
	15″—33.9	15.93	54.6	309.0	30.2	59.7	4.40	10.22	316.5	42.2	4.46
15″—33.9	10″—15.3	14.37	49.2	519.0	51.8	68.6	6.01	10.03	75.1	15.0	2.29
	12″—20.7	15.93	54.6	568.7	53.6	77.5	5.97	10.60	136.3	22.7	2.93
	15″—33.9	19.80	67.8	661.4	56.8	97.8	5.78	11.64	320.8	42.8	4.02
	18″—42.7	22.38	76.6	717.6	58.9	106.0	5.66	12.18	557.2	61.9	4.99
18″—42.7	12″—20.7	18.51	63.4	935.4	76.9	106.5	7.11	12.16	143.1	23.8	2.78
	15″—33.9	22 38	76.6	1086.4	81.5	134.6	6.97	13.33	327.6	43.7	3.83
	18″—42.7	24.96	85.4	1175.6	84.3	147.0	6.86	13.95	564.0	62.7	4.75

Centers of gravity of both channels are in the same vertical line.



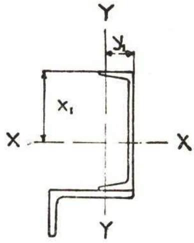
CHANNELS AND ANGLES

PROPERTIES OF SECTIONS

LONG LEG OF ANGLE TURNED OUT

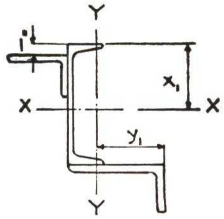
Channel Size and Weight	Angle Size	Total Wt.	Total Area	AXIS X-X					AXIS Y-Y				
				I	$S_1=\frac{I}{y_1}$	$S_2=\frac{I}{y_2}$	r	y_1	I	$S_1=\frac{I}{x_1}$	$S_2=\frac{I}{x_2}$	r	x_1
	In.	Lb.	In.²	In.⁴	In.³	In.³	In.	In.	In.⁴	In.³	In.³	In.	In.
6″— 8.2	2½x2½x¼	12.3	3.58	17.8	8.0	4.7	2.23	2.24	2.6	1.0	1.4	0.86	2.61
	3 x2½x¼	12.7	3.70	18.4	8.5	4.8	2.23	2.17	3.6	1.2	1.9	0.99	3.01
	3½x3 x¼	13.6	3.95	18.9	8.9	4.9	2.19	2.13	4.9	1.4	2.4	1.11	3.40
	3½x3 x5/16	14.8	4.32	19.7	9.8	5.0	2.14	2.02	5.7	1.7	2.7	1.14	3.31
	4 x3 x¼	14.0	4.08	19.4	9.4	4.9	2.18	2.06	6.5	1.7	3.1	1.26	3.79
7″— 9.8	2½x2½x¼	13.9	4.04	28.3	10.6	6.6	2.65	2.68	3.0	1.1	1.6	0.87	2.68
	3 x2½x¼	14.3	4.16	29.1	11.2	6.6	2.64	2.61	4.1	1.3	2.0	0.99	3.09
	3½x3 x¼	15.2	4.41	29.8	11.7	6.7	2.60	2.54	5.4	1.6	2.6	1.11	3.49
	3½x3 x5/16	16.4	4.78	31.0	12.8	6.8	2.55	2.41	6.3	1.8	2.9	1.15	3.40
	4 x3 x¼	15.6	4.54	30.5	12.4	6.7	2.59	2.47	7.1	1.8	3.2	1.25	3.88
	4 x3 x5/16	17.0	4.94	31.8	13.6	6.8	2.54	2.34	8.3	2.2	3.6	1.30	3.78
8″—11.5	3 x2½x¼	16.0	4.67	43.6	14.2	8.8	3.05	3.06	4.6	1.4	2.2	0.99	3.16
	3½x3 x¼	16.9	4.92	44.6	15.0	8.9	3.01	2.98	6.0	1.7	2.8	1.10	3.57
	3½x3 x5/16	18.1	5.29	46.4	16.3	9.0	2.96	2.84	6.9	2.0	3.0	1.14	3.48
	4 x3 x¼	17.3	5.05	45.6	15.7	9.0	3.00	2.91	7.8	2.0	3.4	1.24	3.97
	4 x3 x5/16	18.7	5.45	47.5	17.2	9.1	2.95	2.76	9.0	2.3	3.8	1.29	3.87
	5 x3½x5/16	20.2	5.92	49.5	18.8	9.2	2.89	2.63	14.7	3.2	5.6	1.58	4.64
9″—13.4	3 x2½x¼	17.9	5.20	62.5	17.7	11.4	3.47	3.53	5.2	1.6	2.4	1.00	3.23
	3½x3 x¼	18.8	5.45	63.9	18.6	11.5	3.43	3.44	6.2	1.7	2.7	1.07	3.64
	3½x3 x5/16	20.0	5.82	66.5	20.3	11.6	3.38	3.28	7.7	2.2	3.3	1.15	3.56
	4 x3 x¼	19.2	5.58	65.3	19.4	11.6	3.42	3.36	8.6	2.1	3.6	1.24	4.05
	4 x3 x5/16	20.6	5.98	68.0	21.3	11.7	3.37	3.19	10.0	2.5	4.0	1.29	3.96
	5 x3½x5/16	22.1	6.45	70.7	23.2	11.9	3.31	3.05	15.9	3.4	5.9	1.57	4.74
10″—15.3	3½x3 x¼	20.7	6.03	88.7	22.7	14.6	3.84	3.91	7.5	2.0	3.1	1.11	3.71
	3½x3 x5/16	21.9	6.40	92.2	24.4	14.7	3.79	3.74	8.5	2.4	3.4	1.15	3.63
	4 x3 x¼	21.1	6.16	90.5	23.6	14.7	3.83	3.83	9.4	2.3	3.8	1.23	4.12
	4 x3 x5/16	22.5	6.56	94.2	25.8	14.8	3.79	3.65	10.8	2.7	4.2	1.28	4.03
	5 x3½x5/16	24.0	7.03	97.8	28.0	15.0	3.73	3.49	17.0	3.5	6.1	1.56	4.83
	5 x3½x⅜	25.7	7.52	101.2	30.5	15.4	3.67	3.32	19.3	4.1	6.7	1.60	4.73
12″—20.7	3½x3 x¼	26.1	7.59	163.1	33.1	23.1	4.63	4.93	9.6	2.5	3.7	1.12	3.84
	3½x3 x5/16	27.3	7.96	169.1	35.7	23.3	4.61	4.74	10.8	2.8	4.0	1.16	3.77
	4 x3 x¼	26.5	7.72	166.0	34.2	23.2	4.64	4.85	11.7	2.7	4.4	1.23	4.28
	4 x3 x5/16	27.9	8.12	172.4	37.1	23.4	4.61	4.65	13.3	3.2	4.8	1.28	4.20
	5 x3½x5/16	29.4	8.59	178.6	40.0	23.7	4.56	4.46	19.9	4.0	6.8	1.52	5.02
	5 x3½x⅜	31.1	9.08	184.8	43.3	23.9	4.51	4.27	22.5	4.6	7.4	1.57	4.92
	6 x4 x⅜	33.0	9.64	190.7	46.5	24.1	4.45	4.10	33.1	5.8	10.2	1.85	5.71
	6 x4 x7/16	35.0	10.21	196.5	49.9	24.4	4.39	3.94	36.8	6.6	11.1	1.90	5.61
12″—25	3½x3 x5/16	31.6	9.25	186.3	37.9	26.3	4.49	4.92	11.5	3.0	4.2	1.11	3.82
	4 x3 x¼	30.8	9.01	182.8	36.5	26.2	4.50	5.01	12.3	2.8	4.5	1.17	4.32
	4 x3 x5/16	32.2	9.41	189.8	39.2	26.5	4.49	4.84	14.0	3.3	5.0	1.22	4.25
	5 x3½x5/16	33.7	9.88	196.7	42.2	26.8	4.46	4.66	20.9	4.1	7.0	1.45	5.09
	5 x3½x⅜	35.4	10.37	203.6	45.4	27.1	4.43	4.49	23.6	4.7	7.8	1.51	5.01
	6 x4 x⅜	37.3	10.93	210.3	48.6	27.4	4.39	4.33	34.5	5.9	10.7	1.78	5.81
	6 x4 x7/16	39.3	11.50	216.7	52.0	27.7	4.34	4.17	38.5	6.7	11.6	1.83	5.72
15″—33.9	4 x3 x¼	39.7	11.59	379.8	58.4	44.7	5.72	6.51	16.9	3.8	5.8	1.21	4.49
	4 x3 x5/16	41.1	11.99	392.6	62.1	45.2	5.72	6.32	18.8	4.2	6.3	1.25	4.43
	5 x3½x5/16	42.6	12.46	405.5	66.2	45.7	5.70	6.13	26.3	5.0	8.5	1.45	5.30
	5 x3½x⅜	44.3	12.95	418.6	70.5	46.2	5.69	5.94	29.4	5.6	9.2	1.51	5.22
	6 x4 x⅜	46.2	13.51	431.4	75.0	46.6	5.65	5.75	41.4	6.8	12.4	1.75	6.06
	6 x4 x7/16	48.2	14.08	444.0	79.8	47.0	5.62	5.56	46.0	7.7	13.4	1.81	5.97

LINTELS



Channel	Angle	Weight per Foot	Area	AXIS X-X			AXIS Y-Y		
				I_{xx}	r_{xx}	x_1	I_{yy}*	r_{yy}*	y_1*
		Lbs.	In.^{2}	In.^{4}	In.	In.	In.^{4}	In.	In.
15 ⊔ 33.9	6 x 3½ x 5/16	43.7	12.77	467.2	6.05	9.36	41.9	1.81	1.51
	5 x 3 x 5/16	42.1	12.30	443.6	6.00	9.10	26.9	1.48	1.28
	4 x 3 x ¼	39.7	11.59	412.0	5.96	8.70	16.6	1.20	1.08
	3 x 3 x ¼	38.8	11.34	401.2	5.95	8.56	11.8	1.02	0.96
12 ⊔ 20.7	6 x 3½ x 5/16	30.5	8.90	219.8	4.97	8.18	35.9	2.01	1.76
	5 x 3 x 5/16	28.9	8.43	206.4	4.95	7.90	22.0	1.61	1.45
	4 x 3 x ¼	26.5	7.72	189.5	4.95	7.48	12.3	1.26	1.15
	3 x 3 x ¼	25.6	7.47	183.7	4.96	7.32	7.6	1.01	0.98
	3 x 2½ x ¼	25.2	7.34	176.6	4.90	7.19	7.2	0.99	0.95
10 ⊔ 15.3	6 x 3½ x 5/16	25.1	7.34	127.7	4.17	7.25	32.8	2.11	1.95
	5 x 3 x 5/16	23.5	6.87	119.0	4.16	6.98	19.8	1.70	1.58
	4 x 3 x ¼	21.1	6.16	108.7	4.20	6.57	10.6	1.31	1.22
	3 x 3 x ¼	20.2	5.91	105.2	4.22	6.42	6.0	1.01	1.01
	3 x 2½ x ¼	19.8	5.78	100.1	4.16	6.28	5.6	0.99	0.97
9 ⊔ 13.4	6 x 3½ x 5/16	23.2	6.76	95.8	3.76	6.73	31.6	2.16	2.04
	5 x 3 x 5/16	21.6	6.29	88.8	3.76	6.48	19.0	1.74	1.64
	4 x 3 x ¼	19.2	5.58	81.1	3.81	6.09	10.0	1.34	1.26
	3 x 3 x ¼	18.3	5.33	78.5	3.84	5.94	5.5	1.02	1.03
	3 x 2½ x ¼	17.9	5.20	74.1	3.78	5.80	5.1	0.99	0.98
8 ⊔ 11.5	6 x 3½ x 5/16	21.3	6.23	70.2	3.36	6.19	30.8	2.22	2.12
	5 x 3 x 5/16	19.7	5.76	64.7	3.35	5.95	18.6	1.80	1.69
	4 x 3 x ¼	17.3	5.05	59.0	3.42	5.59	9.4	1.37	1.31
	3 x 3 x ¼	16.4	4.80	57.1	3.45	5.45	5.0	1.02	1.05
	3 x 2½ x ¼	16.0	4.67	53.5	3.38	5.31	4.7	1.00	1.00
7 ⊔ 9.8	6 x 3½ x 5/16	19.6	5.72	49.9	2.95	5.64	28.8	2.24	2.28
	5 x 3 x 5/16	18.0	5.25	45.6	2.95	5.41	17.3	1.81	1.82
	4 x 3 x ¼	15.6	4.54	41.6	3.03	5.08	9.0	1.41	1.37
	3 x 3 x ¼	14.7	4.29	40.3	3.07	4.96	4.7	1.04	1.09
	3 x 2½ x ¼	14.3	4.16	37.4	3.00	4.81	4.3	1.02	1.04
6 ⊔ 8.2	6 x 3½ x 5/16	18.0	5.26	34.2	2.55	5.05	27.3	2.28	2.41
	5 x 3 x 5/16	16.4	4.79	30.9	2.54	4.84	16.4	1.85	1.92
	4 x 3 x ¼	14.0	4.08	28.3	2.63	4.55	8.5	1.44	1.45
	3 x 3 x ¼	13.1	3.83	27.5	2.68	4.44	4.3	1.06	1.14
	3 x 2½ x ¼	12.7	3.70	25.1	2.60	4.29	4.0	1.04	1.08

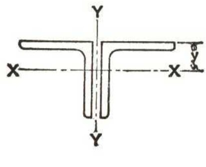
*Based on Nominal Toe of Angle flush with Back of Channel.



EAVE STRUTS

Channel and Top Angle	Bottom Angle	Weight per Foot	Area	AXIS X-X			AXIS Y-Y		
				I_{xx}	r_{xx}	x_1	I_{yy}*	r_{yy}*	y_1*
		Lbs.	In.^{2}	In.^{4}	In.	In.	In.^{4}	In.	In.
8 ⊔ 11.5 and 6x3½x5/16 L	6 x 3½ x 5/16	31.1	9.10	111.6	3.50	4.79	75.1	2.87	5.16
	5 x 3 x 5/16	29.5	8.63	101.1	3.42	4.56	55.7	2.54	4.52
	4 x 3 x ¼	27.1	7.92	88.6	3.34	4.20	40.5	2.26	3.89
	3 x 3 x ¼	26.2	7.67	84.4	3.32	4.07	32.8	2.07	3.09
	3 x 2½ x ¼	25.8	7.54	78.7	3.23	3.96	31.7	2.05	3.14
8 ⊔ 11.5 and 5x3x5/16 L	6 x 3½ x 5/16	29.5	8.63	107.2	3.52	4.94	61.9	2.68	4.91
	5 x 3 x 5/16	27.9	8.16	97.3	3.45	4.69	44.0	2.32	4.28
	4 x 3 x ¼	25.5	7.45	85.5	3.39	4.33	30.3	2.02	3.65
	3 x 3 x ¼	24.6	7.20	81.6	3.37	4.19	23.3	1.80	2.86
	3 x 2½ x ¼	24.2	7.07	76.1	3.28	4.08	22.4	1.78	2.91
8 ⊔ 11.5 and 4x3x¼ L	6 x 3½ x 5/16	27.1	7.92	97.9	3.52	5.24	48.3	2.47	4.57
	5 x 3 x 5/16	25.5	7.45	89.2	3.46	4.99	32.4	2.08	3.95
	4 x 3 x ¼	23.1	6.74	79.1	3.43	4.62	20.5	1.74	3.33
	3 x 3 x ¼	22.2	6.49	75.7	3.42	4.49	14.4	1.49	2.54
	3 x 2½ x ¼	21.8	6.36	70.7	3.33	4.36	13.7	1.47	2.59
8 ⊔ 11.5 and 3x3x¼ L	6 x 3½ x 5/16	26.2	7.67	93.5	3.49	5.38	41.9	2.34	4.41
	5 x 3 x 5/16	24.6	7.20	85.3	3.44	5.13	26.9	1.93	3.79
	4 x 3 x ¼	22.2	6.49	75.9	3.42	4.76	15.8	1.56	3.17
	3 x 3 x ¼	21.3	6.24	72.8	3.41	4.62	10.2	1.28	2.38
	3 x 2½ x ¼	20.9	6.11	67.9	3.33	4.49	9.6	1.25	2.43
8 ⊔ 11.5 and 3x2½x¼ L	6 x 3½ x 5/16	25.8	7.54	93.2	3.51	5.41	41.5	2.35	4.38
	5 x 3 x 5/16	24.2	7.07	85.1	3.47	5.15	26.7	1.94	3.77
	4 x 3 x ¼	21.8	6.36	75.3	3.45	4.78	15.8	1.57	3.15
	3 x 3 x ¼	20.9	6.11	72.7	3.45	4.64	10.2	1.29	2.37
	3 x 2½ x ¼	20.5	5.98	67.9	3.37	4.51	9.6	1.27	2.42

*Based on Nominal Toe of Bottom Angle flush with Back of Channel



TWO EQUAL ANGLES

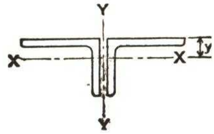
PROPERTIES OF SECTIONS

Size	Thick-ness	Weight per Ft. 2 Angles	Area of 2 Angles	AXIS X-X				RADII OF GYRATION ABOUT AXIS Y-Y — Back to Back of Angles, Inches					
				I	S	r	y	0	1/4	3/8	1/2	5/8	3/4
In.	In.	Lb.	In.²	In.⁴	In.³	In.	In.						
8 x 8	1 1/8	113.8	33.46	195.9	35.1	2.42	2.41	3.42	3.50	3.55	3.60	3.64	3.69
	1	102.0	30.00	178.0	31.6	2.44	2.37	3.40	3.49	3.53	3.58	3.62	3.67
	7/8	90.0	26.46	159.2	28.0	2.45	2.32	3.38	3.46	3.51	3.55	3.60	3.64
	3/4	77.8	22.88	139.5	24.4	2.47	2.28	3.36	3.45	3.49	3.54	3.58	3.63
	5/8	65.4	19.22	118.9	20.6	2.49	2.23	3.34	3.42	3.47	3.51	3.56	3.60
	9/16	59.2	17.36	108.2	18.7	2.50	2.21	3.33	3.41	3.46	3.50	3.55	3.59
	1/2	52.8	15.50	97.3	16.7	2.50	2.19	3.33	3.41	3.45	3.50	3.54	3.59
6 x 6	1	74.8	22.00	70.9	17.1	1.80	1.86	2.59	2.68	2.72	2.77	2.82	2.87
	7/8	66.2	19.46	63.8	15.3	1.81	1.82	2.57	2.66	2.70	2.75	2.80	2.85
	3/4	57.4	16.88	56.3	13.3	1.83	1.78	2.55	2.64	2.68	2.73	2.78	2.82
	5/8	48.4	14.22	48.3	11.3	1.84	1.73	2.53	2.62	2.66	2.71	2.75	2.80
	9/16	43.8	12.86	44.1	10.3	1.85	1.71	2.52	2.60	2.65	2.69	2.74	2.78
	1/2	39.2	11.50	39.8	9.2	1.86	1.68	2.51	2.59	2.64	2.68	2.73	2.77
	7/16	34.4	10.12	35.4	8.1	1.87	1.66	2.50	2.58	2.63	2.67	2.72	2.76
	3/8	29.8	8.72	30.8	7.1	1.88	1.64	2.49	2.58	2.62	2.66	2.71	2.76
5 x 5	7/8	54.4	15.96	35.5	10.3	1.49	1.57	2.17	2.26	2.31	2.35	2.40	2.45
	3/4	47.2	13.88	31.5	9.1	1.51	1.52	2.14	2.23	2.28	2.32	2.37	2.42
	5/8	40.0	11.72	27.2	7.7	1.52	1.48	2.12	2.21	2.26	2.30	2.35	2.40
	1/2	32.4	9.50	22.5	6.3	1.54	1.43	2.10	2.19	2.23	2.28	2.32	2.37
	7/16	28.6	8.36	20.0	5.6	1.55	1.41	2.09	2.18	2.22	2.27	2.31	2.36
	3/8	24.6	7.22	17.5	4.8	1.56	1.39	2.09	2.17	2.22	2.26	2.31	2.35
4 x 4	3/4	37.0	10.88	15.3	5.6	1.19	1.27	1.74	1.83	1.88	1.93	1.98	2.03
	5/8	31.4	9.22	13.3	4.8	1.20	1.23	1.72	1.81	1.86	1.91	1.96	2.01
	1/2	25.6	7.50	11.12	3.9	1.22	1.18	1.70	1.78	1.83	1.88	1.93	1.98
	7/16	22.6	6.62	9.9	3.5	1.23	1.16	1.69	1.77	1.82	1.87	1.92	1.96
	3/8	19.6	5.72	8.7	3.0	1.23	1.14	1.68	1.77	1.81	1.86	1.91	1.95
	5/16	16.4	4.80	7.4	2.6	1.24	1.12	1.67	1.75	1.80	1.84	1.89	1.94
	1/4	13.2	3.88	6.1	2.1	1.25	1.09	1.66	1.74	1.79	1.83	1.88	1.93
3 1/2 x 3 1/2	1/2	22.2	6.50	7.3	3.0	1.06	1.06	1.50	1.59	1.64	1.68	1.73	1.78
	7/16	19.6	5.74	6.5	2.6	1.07	1.04	1.49	1.57	1.62	1.67	1.71	1.76
	3/8	17.0	4.96	5.7	2.3	1.07	1.01	1.48	1.56	1.61	1.66	1.70	1.75
	5/16	14.4	4.18	4.9	2.0	1.08	.99	1.47	1.55	1.60	1.65	1.69	1.74
	1/4	11.6	3.38	4.0	1.6	1.09	.97	1.46	1.55	1.59	1.64	1.68	1.73
3 x 3	1/2	18.8	5.50	4.4	2.1	.90	.93	1.29	1.39	1.43	1.48	1.53	1.58
	7/16	16.6	4.86	4.0	1.9	.91	.91	1.28	1.38	1.42	1.47	1.52	1.57
	3/8	14.4	4.22	3.5	1.7	.91	.89	1.28	1.37	1.41	1.46	1.51	1.56
	5/16	12.2	3.56	3.0	1.4	.92	.87	1.26	1.35	1.40	1.44	1.49	1.54
	1/4	9.8	2.88	2.5	1.2	.93	.84	1.25	1.34	1.38	1.43	1.48	1.53
2 1/2 x 2 1/2	1/2	15.4	4.50	2.5	1.4	.74	.81	1.10	1.19	1.24	1.29	1.34	1.40
	3/8	11.8	3.46	2.0	1.1	.75	.76	1.07	1.16	1.21	1.26	1.31	1.36
	5/16	10.0	2.94	1.7	1.0	.76	.74	1.06	1.15	1.20	1.25	1.30	1.35
	1/4	8.2	2.38	1.4	0.8	.77	.72	1.05	1.14	1.19	1.24	1.29	1.34
2 x 2	3/8	9.4	2.72	1.0	0.7	.59	.64	.87	.97	1.02	1.07	1.12	1.18
	5/16	7.84	2.30	0.8	0.6	.60	.61	.86	.95	1.00	1.05	1.10	1.16
	1/4	6.38	1.88	0.7	0.5	.61	.59	.85	.94	.99	1.04	1.09	1.14

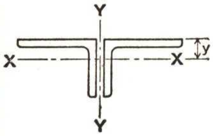
TWO UNEQUAL ANGLES

PROPERTIES OF SECTIONS

SHORT LEGS BACK TO BACK



Size	Thick-ness	Weight per Ft. 2 Angles	Area of 2 Angles	AXIS X-X				RADII OF GYRATION ABOUT AXIS Y-Y Back to Back of Angles, Inches					
				I	S	r	y	0	1/4	3/8	1/2	5/8	3/4
In.	In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.	In.						
9 x 4	1	81.6	24.00	24.0	8.0	1.00	1.00	4.51	4.61	4.66	4.71	4.76	4.80
	7/8	72.2	21.22	21.6	7.2	1.01	.95	4.48	4.58	4.63	4.68	4.73	4.78
	3/4	62.6	18.38	19.2	6.2	1.02	.91	4.46	4.56	4.61	4.65	4.70	4.75
	5/8	52.6	15.46	16.6	5.2	1.04	.86	4.43	4.53	4.58	4.63	4.68	4.73
	9/16	47.6	14.00	15.2	4.8	1.04	.83	4.42	4.51	4.56	4.61	4.66	4.71
	1/2	42.6	12.50	13.8	4.4	1.05	.81	4.41	4.51	4.55	4.60	4.65	4.70
8 x 6	1	88.4	26.00	77.6	17.8	1.73	1.65	3.64	3.73	3.78	3.82	3.87	3.92
	7/8	78.2	22.96	69.7	15.9	1.74	1.61	3.62	3.71	3.76	3.81	3.85	3.90
	3/4	67.6	19.88	61.4	13.8	1.76	1.56	3.60	3.69	3.73	3.78	3.83	3.87
	5/8	57.0	16.72	52.7	11.8	1.77	1.52	3.58	3.67	3.72	3.76	3.81	3.85
	9/16	51.4	15.12	48.1	10.7	1.78	1.50	3.57	3.66	3.70	3.75	3.79	3.84
	1/2	46.0	13.50	43.4	9.6	1.79	1.47	3.56	3.65	3.69	3.74	3.78	3.83
	7/16	40.4	11.86	38.5	8.5	1.80	1.45	3.55	3.64	3.68	3.73	3.77	3.82
8 x 4	1	74.8	22.00	23.3	7.9	1.03	1.05	3.95	4.05	4.10	4.15	4.20	4.25
	7/8	66.2	19.46	21.1	7.0	1.04	1.00	3.93	4.02	4.07	4.12	4.17	4.22
	3/4	57.4	16.88	18.7	6.1	1.05	.95	3.90	3.99	4.04	4.09	4.14	4.19
	5/8	48.4	14.22	16.2	5.2	1.07	.91	3.88	3.98	4.02	4.07	4.12	4.17
	9/16	43.8	12.86	14.8	4.8	1.07	.88	3.87	3.96	4.01	4.06	4.10	4.15
	1/2	39.2	11.50	13.5	4.3	1.08	.86	3.86	3.95	4.00	4.05	4.09	4.14
	7/16	34.4	10.12	12.0	3.8	1.09	.83	3.85	3.94	3.99	4.04	4.07	4.12
7 x 4	7/8	60.4	17.72	20.4	6.9	1.07	1.05	3.37	3.46	3.51	3.56	3.61	3.66
	3/4	52.4	15.38	18.1	6.1	1.09	1.01	3.35	3.44	3.49	3.54	3.59	3.64
	5/8	44.2	12.96	15.7	5.2	1.10	.96	3.32	3.42	3.47	3.51	3.56	3.61
	9/16	40.0	11.74	14.4	4.8	1.11	.94	3.32	3.41	3.46	3.50	3.55	3.60
	1/2	35.8	10.50	13.0	4.2	1.11	.92	3.31	3.40	3.45	3.49	3.54	3.59
	7/16	31.6	9.24	11.6	3.8	1.12	.89	3.29	3.39	3.43	3.48	3.53	3.57
	3/8	27.2	7.96	10.2	3.3	1.13	.87	3.28	3.38	3.42	3.47	3.52	3.56
6 x 4	7/8	54.4	15.96	19.5	6.8	1.11	1.12	2.82	2.92	2.97	3.02	3.06	3.11
	3/4	47.2	13.88	17.4	5.9	1.12	1.08	2.80	2.90	2.95	2.99	3.04	3.09
	5/8	40.0	11.72	15.0	5.1	1.13	1.03	2.78	2.87	2.92	2.97	3.01	3.06
	9/16	36.2	10.62	13.8	4.6	1.14	1.01	2.77	2.86	2.91	2.96	3.00	3.05
	1/2	32.4	9.50	12.5	4.2	1.15	.99	2.76	2.85	2.90	2.95	2.99	3.04
	7/16	28.6	8.36	11.2	3.7	1.16	.96	2.75	2.84	2.88	2.93	2.98	3.03
	3/8	24.6	7.22	9.8	3.2	1.17	.94	2.74	2.83	2.87	2.92	2.97	3.02
6 x 3½	1/2	30.6	9.00	8.5	3.2	.97	.83	2.83	2.92	2.97	3.02	3.07	3.12
	3/8	23.4	6.84	6.7	2.5	.99	.79	2.81	2.90	2.95	3.00	3.05	3.09
	5/16	19.6	5.74	5.7	2.1	1.00	.76	2.80	2.89	2.94	2.99	3.03	3.08
5 x 3½	3/4	39.6	11.62	11.1	4.4	.98	1.00	2.34	2.43	2.48	2.53	2.58	2.63
	5/8	33.6	9.84	9.7	3.8	.99	.95	2.31	2.40	2.45	2.50	2.55	2.60
	1/2	27.2	8.00	8.1	3.1	1.01	.91	2.29	2.38	2.43	2.48	2.53	2.58
	7/16	24.0	7.06	7.3	2.8	1.01	.88	2.28	2.37	2.41	2.46	2.51	2.56
	3/8	20.8	6.10	6.4	2.4	1.02	.86	2.27	2.36	2.40	2.45	2.50	2.55
	5/16	17.4	5.12	5.4	2.0	1.03	.84	2.26	2.35	2.38	2.43	2.48	2.53
5 x 3	1/2	25.6	7.50	5.2	2.3	.83	.75	2.36	2.46	2.50	2.55	2.60	2.65
	3/8	19.6	5.72	4.1	1.8	.84	.70	2.34	2.43	2.48	2.53	2.58	2.63
	5/16	16.4	4.80	3.5	1.5	.85	.68	2.33	2.42	2.47	2.52	2.57	2.62



TWO UNEQUAL ANGLES

PROPERTIES OF SECTIONS

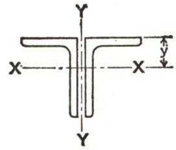
SHORT LEGS BACK TO BACK

Size	Thick-ness	Weight per Ft. 2 Angles	Area of 2 Angles	AXIS X-X				RADII OF GYRATION ABOUT AXIS Y-Y — Back to Back of Angles, Inches					
				I	S	r	y	0	¼	⅜	½	⅝	¾
In.	In.	Lb.	$In.^2$	$In.^4$	$In.^3$	In.	In.						
4 x 3½	⅝	29.4	8.60	9.0	3.7	1.03	1.04	1.77	1.87	1.91	1.96	2.01	2.06
	½	23.8	7.00	7.6	3.0	1.04	1.00	1.76	1.85	1.89	1.94	1.99	2.04
	7/16	21.2	6.18	6.8	2.7	1.05	.98	1.75	1.84	1.89	1.94	1.98	2.03
	⅜	18.2	5.34	6.0	2.3	1.06	.96	1.74	1.83	1.88	1.92	1.97	2.02
	5/16	15.4	4.50	5.1	2.0	1.07	.93	1.73	1.81	1.86	1.91	1.96	2.00
	¼	12.4	3.62	4.2	1.6	1.07	.91	1.72	1.80	1.85	1.90	1.94	1.99
4 x 3	⅝	27.2	7.96	5.7	2.7	.85	.87	1.84	1.94	1.99	2.03	2.08	2.14
	½	22.2	6.50	4.8	2.2	.86	.83	1.82	1.92	1.96	2.01	2.06	2.11
	7/16	19.6	5.74	4.4	2.0	.87	.80	1.81	1.90	1.95	1.99	2.04	2.09
	⅜	17.0	4.96	3.8	1.7	.88	.78	1.80	1.89	1.94	1.98	2.03	2.08
	5/16	14.4	4.18	3.3	1.5	.89	.76	1.79	1.88	1.93	1.97	2.02	2.07
	¼	11.6	3.38	2.7	1.2	.90	.74	1.78	1.87	1.92	1.96	2.01	2.06
3½ x 3	½	20.4	6.00	4.7	2.2	.88	.88	1.56	1.65	1.70	1.75	1.80	1.85
	7/16	18.2	5.30	4.2	2.0	.89	.85	1.54	1.63	1.68	1.73	1.78	1.83
	⅜	15.8	4.60	3.7	1.7	.90	.83	1.53	1.62	1.67	1.72	1.77	1.82
	5/16	13.2	3.86	3.2	1.4	.90	.81	1.52	1.61	1.66	1.71	1.76	1.81
	¼	10.8	3.12	2.6	1.2	.91	.79	1.52	1.61	1.65	1.70	1.75	1.80
3½x2½	½	18.8	5.50	2.7	1.5	.70	.70	1.62	1.71	1.76	1.81	1.86	1.91
	7/16	16.6	4.86	2.5	1.4	.71	.68	1.61	1.70	1.75	1.80	1.85	1.90
	⅜	14.4	4.22	2.2	1.2	.72	.66	1.61	1.69	1.74	1.79	1.84	1.89
	5/16	12.2	3.56	1.9	1.0	.73	.64	1.60	1.68	1.73	1.77	1.82	1.88
	¼	9.8	2.88	1.6	0.8	.74	.61	1.58	1.67	1.71	1.76	1.81	1.86
3 x 2½	½	17.0	5.00	2.6	1.5	.72	.75	1.35	1.45	1.50	1.55	1.60	1.65
	7/16	15.2	4.42	2.4	1.3	.73	.73	1.34	1.44	1.49	1.54	1.59	1.64
	⅜	13.2	3.84	2.1	1.2	.74	.71	1.34	1.43	1.48	1.53	1.58	1.63
	5/16	11.2	3.24	1.8	1.0	.74	.68	1.32	1.41	1.46	1.51	1.56	1.60
	¼	9.0	2.62	1.5	0.8	.75	.66	1.31	1.40	1.45	1.50	1.55	1.60
3 x 2	½	15.4	4.50	1.3	0.9	.55	.58	1.42	1.52	1.57	1.62	1.67	1.73
	7/16	13.6	4.00	1.2	0.8	.55	.56	1.41	1.51	1.56	1.61	1.65	1.71
	⅜	11.8	3.46	1.1	0.7	.56	.54	1.40	1.49	1.54	1.59	1.64	1.69
	5/16	10.0	2.94	0.9	0.6	.57	.52	1.39	1.48	1.53	1.58	1.63	1.68
	¼	8.2	2.38	0.8	0.5	.57	.49	1.38	1.47	1.52	1.57	1.62	1.67
	3/16	6.1	1.80	0.6	0.4	.58	.47	1.37	1.46	1.51	1.56	1.61	1.66
2½ x 2	⅜	10.6	3.10	1.0	0.7	.58	.58	1.13	1.22	1.27	1.32	1.38	1.43
	5/16	9.0	2.62	0.9	0.6	.58	.56	1.12	1.21	1.26	1.31	1.37	1.42
	¼	7.2	2.12	0.7	0.5	.59	.54	1.11	1.20	1.25	1.30	1.35	1.40
	3/16	5.5	1.62	0.6	0.4	.60	.51	1.10	1.19	1.24	1.29	1.34	1.38

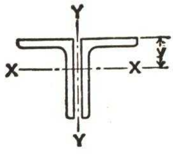
TWO UNEQUAL ANGLES

PROPERTIES OF SECTIONS

LONG LEGS BACK TO BACK



Size	Thickness	Weight per Ft. 2 Angles	Area of 2 Angles	AXIS X-X I	S	r	y	RADII OF GYRATION ABOUT AXIS Y-Y Back to Back of Angles, Inches 0	1/4	3/8	1/2	5/8	3/4
In.	In.	Lb.	In.²	In.⁴	In.³	In.	In.						
9 x 4	1	81.6	24.00	194.0	35.2	2.84	3.50	1.41	1.50	1.55	1.60	1.65	1.70
	7/8	72.2	21.22	173.6	31.4	2.86	3.45	1.39	1.47	1.52	1.57	1.62	1.67
	3/4	62.6	18.38	152.2	27.2	2.88	3.41	1.37	1.45	1.50	1.55	1.59	1.64
	5/8	52.6	15.46	129.8	23.0	2.90	3.36	1.35	1.43	1.47	1.52	1.56	1.61
	9/16	47.6	14.00	118.2	20.8	2.91	3.33	1.33	1.41	1.46	1.50	1.55	1.59
	1/2	42.6	12.50	106.4	18.6	2.92	3.31	1.33	1.41	1.45	1.49	1.54	1.58
8 x 6	1	88.4	26.00	161.6	30.2	2.49	2.65	2.39	2.48	2.52	2.57	2.61	2.66
	7/8	78.2	22.96	144.6	26.8	2.51	2.61	2.37	2.46	2.50	2.55	2.59	2.64
	3/4	67.6	19.88	126.8	23.3	2.53	2.56	2.35	2.44	2.48	2.52	2.57	2.61
	5/8	57.0	16.72	108.2	19.7	2.54	2.52	2.34	2.42	2.46	2.51	2.55	2.60
	9/16	51.4	15.12	98.5	17.9	2.55	2.50	2.33	2.41	2.46	2.50	2.54	2.59
	1/2	46.0	13.50	88.6	16.0	2.56	2.47	2.32	2.40	2.44	2.48	2.53	2.57
	7/16	40.4	11.86	78.4	14.1	2.57	2.45	2.31	2.39	2.43	2.47	2.52	2.56
8 x 4	1	74.8	22.00	139.3	28.1	2.52	3.05	1.47	1.56	1.61	1.66	1.71	1.76
	7/8	66.2	19.46	124.9	25.0	2.53	3.00	1.44	1.53	1.58	1.63	1.68	1.72
	3/4	57.4	16.88	109.8	21.8	2.55	2.95	1.42	1.50	1.55	1.60	1.64	1.69
	5/8	48.4	14.22	93.8	18.4	2.57	2.91	1.40	1.49	1.53	1.58	1.62	1.67
	9/16	43.8	12.86	85.6	16.8	2.58	2.88	1.39	1.47	1.51	1.56	1.60	1.65
	1/2	39.2	11.50	77.0	15.0	2.59	2.86	1.38	1.46	1.51	1.55	1.60	1.64
	7/16	34.4	10.12	68.2	13.2	2.60	2.83	1.37	1.45	1.49	1.53	1.58	1.62
7 x 4	7/8	60.4	17.72	85.8	19.3	2.20	2.55	1.50	1.59	1.64	1.68	1.73	1.78
	3/4	52.4	15.38	75.6	16.8	2.22	2.51	1.48	1.57	1.62	1.66	1.71	1.76
	5/8	44.2	12.96	64.8	14.3	2.24	2.46	1.46	1.55	1.59	1.64	1.68	1.73
	9/16	40.0	11.74	59.2	13.0	2.24	2.44	1.45	1.54	1.58	1.62	1.67	1.72
	1/2	35.8	10.50	53.3	11.6	2.25	2.42	1.45	1.53	1.57	1.62	1.66	1.71
	7/16	31.6	9.24	47.4	10.2	2.26	2.39	1.43	1.51	1.55	1.60	1.65	1.69
	3/8	27.2	7.96	41.1	8.9	2.27	2.37	1.43	1.51	1.55	1.59	1.64	1.68
6 x 4	7/8	54.4	15.96	55.5	14.3	1.86	2.12	1.57	1.66	1.71	1.76	1.81	1.86
	3/4	47.2	13.88	49.0	12.5	1.88	2.08	1.55	1.64	1.69	1.74	1.79	1.84
	5/8	40.0	11.72	42.1	10.6	1.90	2.03	1.53	1.62	1.66	1.71	1.76	1.80
	9/16	36.2	10.62	38.5	9.7	1.90	2.01	1.52	1.61	1.66	1.70	1.75	1.79
	1/2	32.4	9.50	34.8	8.7	1.91	1.99	1.52	1.60	1.65	1.69	1.74	1.78
	7/16	28.6	8.36	31.0	7.7	1.92	1.96	1.50	1.59	1.63	1.68	1.72	1.77
	3/8	24.6	7.22	26.9	6.6	1.93	1.94	1.50	1.58	1.62	1.67	1.71	1.76
6 x 3½	1/2	30.6	9.00	33.2	8.5	1.92	2.08	1.27	1.36	1.40	1.45	1.49	1.55
	3/8	23.4	6.84	25.7	6.5	1.94	2.04	1.26	1.34	1.39	1.43	1.48	1.53
	5/16	19.6	5.74	21.8	5.5	1.95	2.01	1.26	1.33	1.38	1.42	1.46	1.51
5 x 3½	3/4	39.6	11.62	27.8	8.6	1.55	1.75	1.40	1.49	1.54	1.59	1.64	1.69
	5/8	33.6	9.84	24.1	7.3	1.56	1.70	1.37	1.46	1.51	1.56	1.60	1.65
	1/2	27.2	8.00	20.0	6.0	1.58	1.66	1.36	1.44	1.49	1.54	1.58	1.63
	7/16	24.0	7.06	17.8	5.3	1.59	1.63	1.35	1.43	1.47	1.52	1.57	1.62
	3/8	20.8	6.10	15.6	4.6	1.60	1.61	1.34	1.42	1.46	1.51	1.55	1.60
	5/16	17.4	5.12	13.2	3.9	1.61	1.59	1.33	1.41	1.45	1.50	1.54	1.59
5 x 3	1/2	25.6	7.50	18.9	5.8	1.59	1.75	1.11	1.21	1.25	1.30	1.35	1.40
	3/8	19.6	5.72	14.7	4.5	1.61	1.70	1.09	1.18	1.23	1.27	1.32	1.37
	5/16	16.4	4.80	12.5	3.8	1.61	1.68	1.09	1.17	1.22	1.26	1.31	1.36



TWO UNEQUAL ANGLES

PROPERTIES OF SECTIONS

LONG LEGS BACK TO BACK

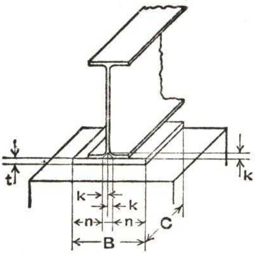
Size	Thickness	Weight per Ft. 2 Angles	Area of 2 Angles	AXIS X-X				RADII OF GYRATION ABOUT AXIS Y-Y					
				I	S	r	y	Back to Back of Angles, Inches					
								0	¼	⅜	½	⅝	¾
In.	In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.	In.						
4 x 3½	⅝	29.4	8.60	12.7	4.7	1.22	1.29	1.46	1.55	1.60	1.65	1.70	1.75
	½	23.8	7.00	10.6	3.9	1.23	1.25	1.44	1.53	1.58	1.63	1.67	1.72
	7/16	21.2	6.18	9.5	3.4	1.24	1.23	1.44	1.52	1.57	1.62	1.66	1.71
	⅜	18.2	5.34	8.4	3.0	1.25	1.21	1.43	1.52	1.56	1.61	1.66	1.70
	5/16	15.4	4.50	7.1	2.5	1.26	1.18	1.42	1.50	1.55	1.59	1.64	1.69
	¼	12.4	3.62	5.8	2.1	1.27	1.16	1.41	1.49	1.54	1.58	1.63	1.67
4 x 3	⅝	27.2	7.96	12.1	4.6	1.23	1.37	1.22	1.31	1.36	1.41	1.46	1.51
	½	22.2	6.50	10.1	3.8	1.25	1.33	1.20	1.29	1.33	1.38	1.43	1.48
	7/16	19.6	5.74	9.0	3.4	1.25	1.30	1.18	1.27	1.32	1.36	1.41	1.46
	⅜	17.0	4.96	7.9	2.9	1.26	1.28	1.18	1.26	1.31	1.35	1.40	1.45
	5/16	14.4	4.18	6.8	2.5	1.27	1.26	1.17	1.25	1.30	1.35	1.39	1.44
	¼	11.6	3.38	5.5	2.0	1.28	1.24	1.16	1.25	1.29	1.34	1.38	1.43
3½ x 3	½	20.4	6.00	6.9	2.9	1.07	1.13	1.25	1.34	1.38	1.43	1.48	1.53
	7/16	18.2	5.30	6.2	2.6	1.08	1.10	1.23	1.32	1.37	1.41	1.46	1.51
	⅜	15.8	4.60	5.4	2.3	1.09	1.08	1.22	1.31	1.36	1.40	1.45	1.50
	5/16	13.2	3.86	4.7	1.9	1.10	1.06	1.22	1.30	1.35	1.39	1.44	1.49
	¼	10.8	3.12	3.8	1.6	1.11	1.04	1.21	1.29	1.34	1.38	1.43	1.48
3½x2½	½	18.8	5.50	6.5	2.8	1.09	1.20	.99	1.08	1.13	1.18	1.23	1.29
	7/16	16.6	4.86	5.8	2.5	1.09	1.18	.98	1.07	1.12	1.17	1.22	1.27
	⅜	14.4	4.22	5.1	2.2	1.10	1.16	.97	1.07	1.11	1.16	1.21	1.26
	5/16	12.2	3.56	4.4	1.9	1.11	1.14	.96	1.05	1.10	1.15	1.20	1.24
	¼	9.8	2.88	3.6	1.5	1.12	1.11	.95	1.04	1.09	1.13	1.18	1.23
3 x 2½	½	17.0	5.00	4.2	2.1	.91	1.00	1.04	1.14	1.18	1.23	1.28	1.34
	7/16	15.2	4.42	3.8	1.9	.92	.98	1.03	1.12	1.17	1.22	1.27	1.33
	⅜	13.2	3.84	3.3	1.6	.93	.96	1.02	1.11	1.16	1.21	1.26	1.31
	5/16	11.2	3.24	2.8	1.4	.94	.93	1.01	1.10	1.14	1.19	1.24	1.29
	¼	9.0	2.62	2.3	1.1	.95	.91	1.00	1.09	1.13	1.18	1.23	1.28
3 x 2	½	15.4	4.50	3.8	2.0	.92	1.08	.80	.89	.94	1.00	1.04	1.10
	7/16	13.6	4.00	3.5	1.8	.93	1.06	.79	.88	.93	.98	1.03	1.09
	⅜	11.8	3.46	3.1	1.6	.94	1.04	.78	.87	.92	.97	1.02	1.07
	5/16	10.0	2.94	2.6	1.3	.95	1.02	.77	.86	.90	.95	1.00	1.06
	¼	8.2	2.38	2.2	1.1	.96	.99	.75	.84	.89	.93	.99	1.04
	3/16	6.14	1.80	1.7	0.8	.97	.97	.75	.83	.88	.93	.98	1.03
2½ x 2	⅜	10.6	3.10	1.8	1.1	.77	.83	.82	.91	.96	1.01	1.06	1.11
	5/16	9.0	2.62	1.6	0.9	.78	.81	.81	.91	.95	1.00	1.05	1.10
	¼	7.2	2.12	1.3	0.8	.78	.79	.80	.89	.94	.99	1.04	1.09
	3/16	5.5	1.62	1.0	0.6	.79	.76	.79	.88	.92	.96	1.02	1.07

BEAM BEARING PLATES

When a beam is supported by a masonry wall or pier it is essential that the beam reaction be distributed over an area sufficient to keep the average pressure on the masonry within the allowable limits. Steel bearing plates are generally used for this purpose.

Standard sizes of rolled steel bearing plates are listed on page 60. These sizes should be used wherever possible.

The following method of design, using a maximum bending stress of 20,000 pounds per square inch, is recommended.



R = Reaction of beam, in kips.
A = B×C = Area of plate, in square inches.
t = Thickness of plate, in inches.
p = Bearing pressure on masonry, in kips per square inch.
k = Distance from outer face of beam flange to web toe of fillet in inches.

1. Determine the required area A = R/p.

When p is not given in the building code or specification, a bearing value may be obtained from the table on page 346.

2. Determine C and solve for B.

The length of bearing, C, is usually governed by the available wall thickness or some other structural consideration.

3. Determine n, and solve for t^2 by substituting in the formula $t^2 = .15pn^2$.

Example: An 18 WF 50 beam has a span of 16 feet and supports a uniform load of 69 kips including its own weight. One end of the beam rests on a masonry wall with an allowable bearing pressure of .250 kips per square inch. The length of bearing C is limited to 10 inches. Design the bearing plate.

$R = \frac{69}{2} = 34.5$ kips

$A = \frac{34.5}{.250} = 138$ sq. in.

$B = \frac{138}{10} = 13.8''$; use 14″

$n = \frac{14''}{2} - 1\frac{1}{16}'' = 5\frac{15}{16}''$—say 6″

$p = \frac{34.5}{14 \times 10} = .246$ kips per sq. in.

$t^2 = .15 \times .246 \times 6 \times 6 = 1.33$ in.^{2}

$t = 1.15''$; use $1\frac{1}{4}''$

Use $10'' \times 1\frac{1}{4}'' \times 1'$-$2''$ Bearing Plate.

Steel bearing plates may be materially reduced in size and weight by setting them upon strong masonry, locally built into the wall or pier to distribute the load over the weaker masonry. For this purpose, templates of bluestone or other hard stone, or rich concrete masonry may be used. In designing such masonry the overhang of any course beyond the course above should not exceed 3/4 of the thickness of the course and the stronger masonry should be carried down far enough to obtain an adequate base area on the weaker masonry.

Steel beams supported by masonry should always be properly anchored to the wall. Recommended details are shown on page 155.

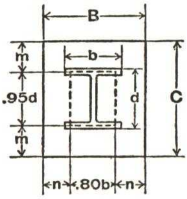
Some designers prefer to compute the required section modulus of bearing plates. The table on page 60 will be found useful for this purpose.

COLUMN BASE PLATES

Steel base plates are generally used under columns for distributing the column loads over a sufficient area of the concrete foundations.

Standard sizes of rolled steel base plates are listed on page 60. These sizes should be used wherever possible. For many of the heavier columns, single or double tier grillages may often be found to be lighter and more economical than base plates on concrete.

The following method of design, using a maximum bending stress of 20,000 pounds per square inch, is recommended.



P = Total column load, in kips.

A = B×C = Area of plate, in square inches.

t = Thickness of plate, in inches.

p = Bearing pressure on foundation, in kips per square inch.

The column load, P, is assumed to be uniformly distributed within a rectangle whose dimensions are .95 d and .80 b, and the base plate is assumed to have a uniform bearing pressure, p, on the foundation.

1. Determine the required area A = P/p.
2. Determine B and C so that dimensions m and n are approximately equal.
3. Determine m and n, the projections of the plate beyond the assumed dotted rectangle, and use the larger value to solve for t by one of the following formulas:

$$t^2 = .15\,pm^2 \qquad \text{or} \qquad t^2 = .15\,pn^2$$

Example: A 14WF 95 column has a reaction of 450 kips and rests on a concrete foundation with an allowable bearing pressure of .600 kips per square inch. Design a steel base plate for this column.

$$A = \frac{450}{.600} = 750 \text{ sq. in.}$$

Assume C = 28″

$$B = \frac{750}{28} = 26.8''\text{; use } 27''$$

$$.95d = .95 \times 14.12 = 13.4''$$
$$.80b = .80 \times 14.545 = 11.6''$$

$$m = \frac{28-13.4}{2} = 7.3''$$

$$n = \frac{27-11.6}{2} = 7.7''$$

$$p = \frac{450}{27 \times 28} = .595 \text{ kips per sq. in.}$$

$$t^2 = .15 \times .595 \times 7.7 \times 7.7 = 5.29 \text{ in.}^2$$

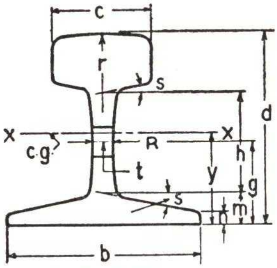
t = 2.30″; use 3″

Use 28″×3″×2′-3″ Base Plate

The column base plate tables, pages 249 to 251, are for base plates on concrete foundations, for allowable bearing values of 600 and 800 pounds per square inch and the maximum values given in the column load tables.

Some designers prefer to compute the required section modulus of base plates. The table on page 60 will be found useful for this purpose.

CRANE RAILS

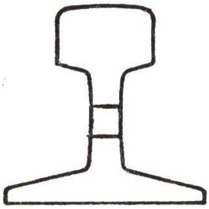


A. S. C. E.

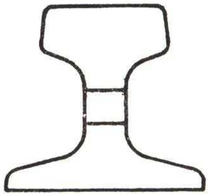
A. R. A.

A. R. E. A.

BETHLEHEM 104 LB.



U. S. STEEL 105 LB.



BETHLEHEM 171 LB.

U. S. STEEL 175 LB.

Nomenclature of sketch for A. S. C. E. Rails also applies to other sections.

The A. S. C. E. rails and the 104-175 lb. rails tabulated below are recommended for crane runway use.

Other rails, of girder type, though not recommended for crane runways, are much used in track, and their dimensions are given as a convenience to draftsmen. For complete details of rail contours consult the rail manufacturer.

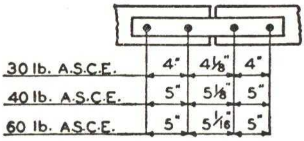
Whenever possible, crane rails should be ordered by complete length of run, allowing the manufacturer to determine the lengths of individual pieces.

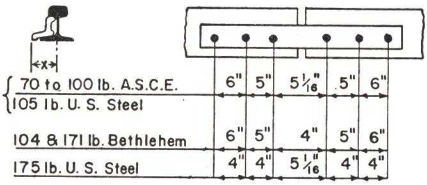
Type	Weight per Yard, in Pounds	DIMENSIONS IN INCHES												PROPERTIES			
			BASE				HEAD			WEB					On Horiz. Axis		
		Depth	Width	Thickness		Slope in (Degr's)	Width c		Radius	Min. Thick.		Radius	Gage	Gross Area	I	S	y
		d	b	m	n	s	Top	Bot.	r	t	h	R	g	In.²	In.⁴	In.³	In.
A.S.C.E.	30	3 1/8	3 1/8	17/32	11/64	13	1 11/16	1 11/16	12	21/64	1 23/32	12	1 25/64	3.00	4.1	2.5	1.52
"	40	3 1/2	3 1/2	5/8	7/32	13	1 7/8	1 7/8	12	25/64	1 55/64	12	1 71/128	3.94	6.6	3.6	1.68
"	60	4 1/4	4 1/4	49/64	9/32	13	2 3/8	2 3/8	12	31/64	2 17/64	12	1 115/128	5.93	14.6	6.6	2.05
"	70	4 5/8	4 5/8	13/16	9/32	13	2 7/16	2 7/16	12	33/64	2 15/32	12	2 3/64	6.81	19.7	8.2	2.22
"	80	5	5	7/8	19/64	13	2 1/2	2 1/2	12	35/64	2 5/8	12	2 3/16	7.86	26.4	10.1	2.38
"	85	5 3/16	5 3/16	57/64	19/64	13	2 9/16	2 9/16	12	9/16	2 3/4	12	2 17/64	8.33	30.1	11.1	2.47
"	90	5 3/8	5 3/8	59/64	19/64	13	2 5/8	2 5/8	12	9/16	2 55/64	12	2 45/128	8.83	34.4	12.2	2.55
"	100	5 3/4	5 3/4	31/32	5/16	13	2 3/4	2 3/4	12	9/16	3 5/64	12	2 65/128	9.84	44.0	14.6	2.73
Bethlehem	104	5	5	1 1/16	1/2	13	2 1/2	2 1/2	12	1	2 7/16	3 1/2	2 7/16	10.29	29.7	10.6	2.21
U. S. Steel	105	5 3/16	5 3/16	1	13/32	13	2 9/16	2 9/16	12	15/16	2 13/32	12	2 13/64	10.30	34.4	12.4	2.41
Bethlehem	171	6	6	1 1/4	5/8	12	4	4 7/16	Flat	1 1/4	2 3/4	Vert.	2 5/8	16.85	73.6	24.5	3.01
U. S. Steel	175	6	6	1 9/64	1/2	12	4	4 1/4	24	1 1/2	3 7/64	Comp.	2 21/32	17.15	71.5	23.7	3.02
A.R.A.-A.	90	5 5/8	5 1/8	1	23/64	14	2 13/32	2 9/16	14	9/16	3 5/32	14	2 37/64	8.82	38.7	12.6	2.54
"	100	6	5 1/2	1 1/16	3/8	14	2 19/32	2 3/4	14	9/16	3 3/8	14	2 3/4	9.84	48.9	15.0	2.75
A.R.A.-B.	100	5 41/64	5 9/64	1 5/64	31/64	13	2 9/16	2 21/32	12	9/16	2 55/64	12	2 65/128	9.85	41.3	13.7	2.63
A.R.E.A.	100	6	5 3/8	1 1/16	25/64	14	2 9/16	2 11/16	14	9/16	3 9/32	14	2 45/164	9.95	49.0	15.1	2.75
"	115	6 5/8	5 1/2	1 1/8	7/16	14	2 21/32	2 23/32	10	5/8	3 13/16	Comp.	2 7/8	11.25	65.6	18.0	2.98
"	132	7 1/8	6	1 3/16	7/16	14	2 15/16	3	10	21/32	4 3/16	Comp.	3 3/32	12.85	88.2	22.5	3.20

CRANE RAIL SPLICES AND FASTENINGS

SPLICES

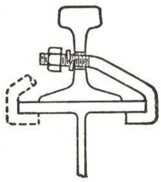
For splice bar contours consult rail manufacturer. Many bars require cutting of bottom flange to clear girder rivet heads. Splice bars are used in pairs. Rails have circular and splice bars have slotted holes to provide for expansion. Bolts should have spring washers under nuts



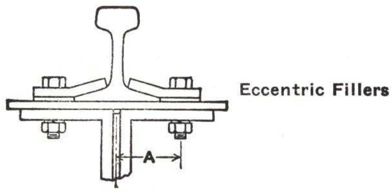


Unless otherwise specified, mill will drill for and furnish standard splice bars; for crane up to 25 tons capacity, however, some fabricators use flat bars.

FASTENINGS



Hook Bolts



Clamps

The two types of fastenings illustrated above incorporate adjustable features for the alignment of the rails, such as length of thread for hook bolts or one-hole eccentric fillers for clamps.

Use bolts with hexagon heads and nuts, and spring washers or other locking device.

Two bolt connections should always be used for each clamp.

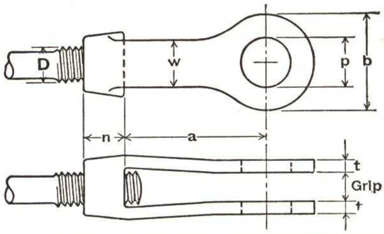
Hook bolts are used only on beams with flange too narrow to permit the use of clamps.

Spacing between pairs of fastenings is in general: hook bolts about 2 feet on centers of pairs, 3 inches between bolts of a pair; clamps 3 feet centers up to 100-tons capacity, then 2 feet centers.

The fabricator should always be consulted as to the type of fastenings shown, or any other type, which he manufactures and recommends.

Weight per Yard in Pound	Type	Standard Splices							Hook Bolts		Clamps (Two Bolts per Plt.)		
		Clearance Dimension x	Bolts			Length of Bar	Weight		Diameter	Weight per Pair	Diameter of Bolts	Minimum A	Weight 2 Plates 4 Fills No Bolts
			No.	Dia.	Lgth.		2 Bars	Set of Bolts and Washers					
30	A.S.C.E.	2	4	⅝	2¾	16⅛	10.5	1.9	⅝	1.8	¾	2 13/16	5
40	A.S.C.E.	2¼	4	¾	3¼	20	16.1	3.0	¾	2.6	¾	3	5
60	A.S.C.E.	2¾	4	¾	4	24	32.4	3.3	⅞	3.8	¾	3⅜	6
70	A.S.C.E.	3	6	¾	4	34	54.6	5.4	⅞	4.0	⅞	3 9/16	8
80	A.S.C.E.	3¼	6	⅞	4½	34	62.6	7.5	⅞	4.0	⅞	3¾	8
85	A.S.C.E.	3⅜	6	⅞	4½	34	67.6	7.5	⅞	4.2	⅞	3⅞	8
90	A.S.C.E.	3½	6	1	4¾	34	72.7	11.4	⅞	4.2	⅞	3 15/16	8
100	A.S.C.E.	3⅝	6	1	5	34	85.7	11.7			1	4⅛	11
104	Beth.	3½	6	1	5	34	60.6	10.7			1	3⅞	11
105	U. S. Steel	2⅝	6	⅞	4½	34	54.6	7.5			1	3⅞	11
171	Beth.	3	6	1	6	34	76.7	12.2			1	4⅜	12
175	U. S. Steel	4	6	1⅛	6½	26	79.6	18.2			1	4¼	12

CLEVISES



Thread: American Standard-Class 2 Fit

Grip = thickness plate + ¼″

Clevis Number	Dimensions, Inches							Weight Pounds
	Max. D	Max. p	b	n	a	w	t	
2½	⅞	1¼	2½	1	5	1¼	⅜	2.5
3	1¼	1½	3	1¼	5	1½	½	4.0
3½	1½	1¾	3½	1½	6	1¾	½	6.0
4	1¾	2	4	1¾	6	2	½	8.0
5	2⅛	2½	5	2¼	7	2½	⅝	16.0
6	2⅝	3	6	2¾	8	3	¾	26.0
7	3	3½	7	3	9	3½	⅞	36.0
8	4	4¼	8	4	10	4	1¼	71.0

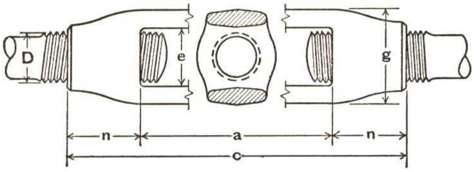
CLEVIS NUMBERS FOR VARIOUS RODS AND PINS

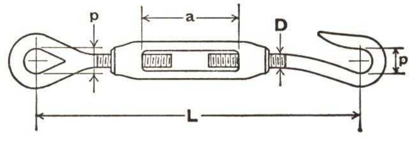
Upset Rods Nominal Size		Diameter of Tap D	Diameter of Pin, Inches														
Round	Square		⅞	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4	4¼
		⅝	2½	2½	2½												
		¾	2½	2½	2½												
		⅞	2½	2½	2½												
¾		1	—	3	3	3	3½										
	¾	1⅛	—	3	3	3	3½										
⅞	⅞	1¼	—	3	3	3	3½	4									
1		1⅜	—	—	3½	3½	3½	4									
1⅛	1	1½	—	—	3½	3½	4	4	5								
1¼	1⅛	1⅝	—	—	—	4	4	5	5	5							
1⅜		1¾	—	—	—	4	5	5	5	5							
	1¼	1⅞	—	—	—	5	5	5	5	5							
1½	1⅜	2	—	—	—	5	5	5	5	6	6						
1⅝		2⅛	—	—	—	5	5	5	6	6	6	6					
1¾	1½	2¼	—	—	—	—	—	6	6	6	6	6	7	7			
1⅞	1⅝	2⅜	—	—	—	—	—	6	6	6	6	7	7	7	8		
2	1¾	2½	—	—	—	—	—	6	6	6	7	7	7	7	8		
2⅛		2⅝	—	—	—	—	—	—	—	7	7	7	7	7	8		
	1⅞	2¾	—	—	—	—	—	—	—	7	7	7	7	8	8		
2¼	2	2⅞	—	—	—	—	—	—	—	7	7	7	8	8	8	8	8
2⅜	2⅛	3	—	—	—	—	—	—	—	7	7	8	8	8	8	8	8
		3⅛	—	—	—	—	—	—	—	—	8	8	8	8	8	8	8
2½-2⅝	2¼	3¼	—	—	—	—	—	—	—	—	8	8	8	8	8	8	8
		3⅜	—	—	—	—	—	—	—	—	8	8	8	8	8	8	8*
2¾	2⅜	3½	—	—	—	—	—	—	—	—	8	8	8	8	8	8*	8*
		3⅝	—	—	—	—	—	—	—	—	8	8	8	8	8*	8*	8*
2⅞-3	2½-2⅝	3¾	—	—	—	—	—	—	—	—	8	8	8	8*	8*	8*	8*
		3⅞	—	—	—	—	—	—	—	—	—	8*	8*	8*	8*	8*	8*
3⅛-3¼	2¾	4	—	—	—	—	—	—	—	—	—	8*	8*	8*	8*		

Above Table of Clevis Sizes is based on the Net Area of Clevis through Pin Hole being equal to or greater than 135 per cent of Net Area of Rod. Table applies to round and square rods with upset ends and round rods without upset ends; * denotes that clevis is not sufficient for round rods not upset. Pins are sufficient for shear but must be investigated for bending. For other combinations of pin and rod or net area ratios, required clevis size can be calculated by reference to the tabulated dimensions.

Weights and dimensions of clevises are Cleveland City Forge Co. Standard. Similar products of other manufacturers are essentially the same.

TURNBUCKLES AND SLEEVE NUTS



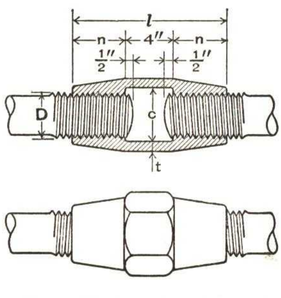


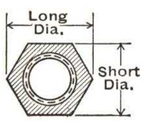
Thread: American Standard-Class 2 Fit

Size D In.	Standard Turnbuckles Dimensions, Inches					Weight of Turnbuckles, Lb. Length, a, Inches							Eye and Hook Stubs			
	a	n	c	e	g	6	9	12	18	24	36	48	Std. p In.	(av.) for a=6″	Weight Lb. Eye	Weight Lb. Hook
3/8	6	9/16	7 1/8	9/16	1 1/32	.41	......	......	......	......	......	......	3/4	19	.30	.25
1/2	6	3/4	7 1/2	11/16	1 5/16	.70	.75	1.00	......	......	......	......	1	19	.61	.48
5/8	6	29/32	7 13/16	13/16	1 1/2	.89	1.38	1.50	......	......	......	......	1 1/4	19 1/2	1.07	.95
3/4	6	1 1/16	8 1/8	15/16	1 23/32	1.20	1.63	2.13	3.06	4.38	......	......	1 1/2	21	1.70	1.52
7/8	6	1 7/32	8 7/16	1 3/32	1 7/8	1.46	......	2.83	4.33	5.47	......	......	1 3/4	23 1/4	2.44	2.19
1	6	1 3/8	8 3/4	1 9/32	2 1/32	2.27	......	3.80	4.13	4.45	5.12	......	2	24 1/2	3.42	3.10
1 1/8	6	1 9/16	9 1/8	1 13/32	2 9/32	2.72	......	4.00	7.25	9.15	12.95	......	2 1/4	26 1/4	4.92	4.50
1 1/4	6	1 3/4	9 1/2	1 9/16	2 17/32	3.58	......	4.70	7.13	12.11	16.75	......	2 1/2	28	6.35	5.82
1 3/8	6	1 15/16	9 7/8	1 11/16	2 3/4	4.13	......	......	......	......	......	......	2 3/4	30	8.42	7.79
1 1/2	6	2 1/8	10 1/4	1 27/32	3 1/32	5.25	......	8.00	9.13	11.75	17.75	24.00	3	32	10.83	10.08
1 5/8	6	2 1/4	10 1/2	1 31/32	3 9/32	5.88	......	......	......	......	......	......	3 1/4	34	13.91	12.94
1 3/4	6	2 1/2	11	2 1/8	3 9/16	7.05	......	......	15.00	21.59	29.35	37.85	3 1/2	35	17.40	16.38
1 7/8	6	2 3/4	11 1/2	2 3/8	4	9.95	......	......	......	......	......	......	3 3/4	37 1/2	20.62	19.45
2	6	2 3/4	11 1/2	2 3/8	4	9.95	......	15.23	......	28.35	37.95	48.45	4	40 1/2	25.45	24.13
2 1/4	6	3 3/8	12 3/4	2 11/16	4 5/8	18.00	......	......	......	37.80	51.00	63.95	4 1/2	43 1/2	39.02	37.35
2 1/2	6	3 3/4	13 1/2	3	5	23.25	......	......	......	49.38	65.30	82.50	5	50	57.02	54.94
2 3/4	6	4 1/8	14 1/4	3 1/4	5 5/8	31.50	......	......	......	......	......	104.30	5 1/2	55	81.80	79.28
3	6	4 1/2	15	3 5/8	6 1/8	39.50	......	......	......	......	......	126.40	6	60	106.06	103.06
3 1/4	6	5 1/4	16 1/2	3 7/8	6 3/4	61.00	70.00	......	......	......	......	......	......	......	......	......
3 1/2	6	5 1/4	16 1/2	3 7/8	6 3/4	61.00	70.00	......	......	......	......	203.00	......	......	......	......
3 3/4	6	6	18	4 3/4	8 1/2	89.00	......	......	......	......	......	......	......	......	......	......
4	6	6	18	4 3/4	8 1/2	89.00	......	......	......	......	......	314.00	......	......	......	......
4 1/4	9	6 3/4	22 1/2	5 1/4	9 3/4	......	152.00	......	......	......	......	......	......	......	......	......
4 1/2	9	6 3/4	22 1/2	5 1/4	9 3/4	......	152.00	......	......	......	......	......	......	......	......	......
4 3/4	9	6 3/4	22 1/2	5 1/4	9 3/4	......	152.00	......	......	......	......	......	......	......	......	......
5	9	7 1/2	24	6	10	......	200.00	......	......	......	......	......	......	......	......	......

Weights and dimensions of Turnbuckles, Eyes and Hooks are Cleveland City Forge Company Standard. Similar products of other companies are essentially the same.

SLEEVE NUTS

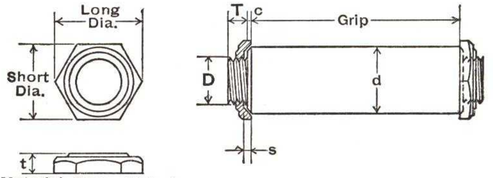




Thread: American Standard-Class 2 Fit
Material: Cast Steel

Dia. of Screw D	Long Dia.	Nut n	Clear c	Short Dia.	Thickness t	Length l	Wt.
In.	In.	In.	In.	In.	In.	In.	Lb.
4	7 1/16	4 1/2	4 1/8	6 1/8	1	13	55
4 1/4	7 1/2	4 3/4	4 3/8	6 1/2	1 1/16	13 1/2	65
4 1/2	7 15/16	5	4 3/4	6 7/8	1 1/16	14	75
4 3/4	8 3/8	5 1/4	5	7 1/4	1 1/8	14 1/2	98
5	8 7/8	5 1/2	5 1/4	7 5/8	1 3/16	15	110
5 1/4	9 1/4	5 3/4	5 1/2	8	1 1/4	15 1/2	122
5 1/2	9 3/4	6	5 3/4	8 3/8	1 5/16	16	142
5 3/4	10 1/8	6 1/4	6	8 3/4	1 3/8	16 1/2	157
6	10 5/8	6 1/2	6 1/4	9 1/8	1 7/16	17	176

RECESSED PIN NUTS AND COTTER PINS

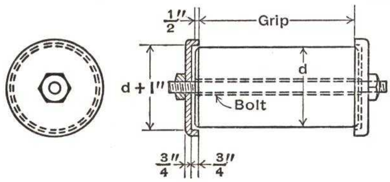


Material: Pressed Steel

Thread
Shape: American Standard
Class 2 Fit
Pitch: 6 per inch

Diameter of Pin d	PIN			NUT						
	Thread			Thickness t	Diameter		Recess		Diameter Rough Hole	Weight Pounds
	D	T	c		Short Dia.	Long Dia.	Rough Dia.	s		
2 2¼	1½	1	⅛	⅞	3	3⅜	2⅝	¼	1¼	1
2½ 2¾	2	1⅛	⅛	1	3⅝	4⅛	3⅛	¼	1¾	2
3 *3¼ 3½	2½	1¼	⅛	1⅛	4⅜	5	3⅞	⅜	2¼	3
*3¾ 4	3	1⅜	¼	1¼	4⅞	5⅝	4⅜	⅜	2¾	4
*4¼ 4½ *4¾	3½	1½	¼	1⅜	5¾	6⅝	5¼	½	3¼	5
5 *5¼	4	1⅝	¼	1½	6¼	7¼	5¾	½	3¾	6
5½ *5¾ 6	4½	1¾	¼	1⅝	7	8⅛	6½	⅝	4¼	8
*6¼ *6½	5	1⅞	⅜	1¾	7⅝	8⅞	7	⅝	4¾	10
*6¾ 7	5½	2	⅜	1⅞	8⅛	9⅜	7½	¾	5¼	12
*7¼ *7½	5½	2	⅜	1⅞	8⅝	10	8	¾	5¼	14
*7¾ 8 *8¼	6	2¼	⅜	2⅛	9⅜	10⅞	8¾	¾	5¾	19
*8½ *8¾ 9	6	2¼	⅜	2⅛	10¼	11⅞	9⅝	¾	5¾	24
*9¼ *9½	6	2⅜	⅜	2¼	11¼	13	10⅝	¾	5¾	32
*9¾ 10	6	2⅜	⅜	2¼	11¼	13	10⅝	¾	5¾	32

*Special Sizes

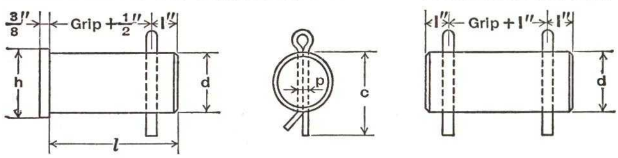


TYPICAL PIN CAP DETAIL FOR PINS OVER 10 INCHES IN DIAMETER
Dimensions shown are approximate.

Recessed Pin Nuts similar to those listed above are available, in cast steel, for pins up to 24 inches in diameter.

For pins over 10 inches in diameter, however, the preferred practice is a detail similar to that shown at the left, in which the pin is held in place by a recessed cap at each end and secured by a bolt passing completely through the caps and pin. Suitable provision must be made for attaching pilots and driving nuts.

HORIZONTAL OR VERTICAL PIN — HORIZONTAL PIN

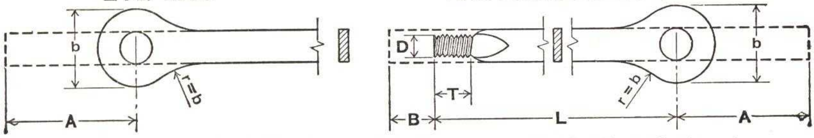


l = Length of Pin, in inches.

Pin Dia. d	PINS WITH HEADS		COTTER			Pin Dia. d	PINS WITH HEADS		COTTER		
	Head Dia. h	Weight of One. Lb.	Length c	Dia. p	Weight per 100. Lb.		Head Dia. h	Weight of One. Lb.	Length c	Dia. p	Weight per 100. Lb.
1¼	1½	.19 + .35*l*	2	¼	2.64	2¾	3⅛	.82 + 1.68*l*	4	⅜	11.4
1½	1¾	.26 + .50*l*	2½	¼	3.10	3	3½	1.02 + 2.00*l*	5	½	28.5
1¾	2	.33 + .68*l*	2¾	¼	3.50	3¼	3¾	1.17 + 2.35*l*	5	½	28.5
2	2⅜	.47 + .89*l*	3	⅜	9.00	3½	4	1.34 + 2.73*l*	6	½	33.8
2¼	2⅝	.58 + 1.13*l*	3¼	⅜	9.40	3¾	4¼	1.51 + 3.13*l*	6	½	33.8
2½	2⅞	.70 + 1.39*l*	3¾	⅜	10.9						

EYE BARS

EYE BAR — ADJUSTABLE EYE BAR



Minimum length, L, for short end is 6′-6″, preferably 7′-0″. Left thread.

Thread: American Standard—Class 2 Fit

HEADS FOR ALL BARS

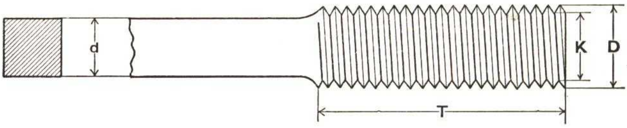
Size of Bar: Width In.	Thickness Max. In.	Thickness Min. In.	Head: Dia. b In.	Head: Max. Pin In.	Head: Excess Head over Bar %	Add. Material A Ft. In.
			4½	1¾		0-10½
2	1	½	5½	2¾	37.5	1- 2½
			* 6½	3¾		1- 7½
			6	2½		1- 1¾
2½	1	⅝	7	3½	40.0	1- 5¾
			* 8	4½		1-10¾
			7½	3¼		1- 4½
3	1½	⅝	8½	4¼	41.7	1- 9½
			* 9½	5¼		2- 2½
		¾	10	4½		1- 9
4	1¾	⅞	11	5½	37.5	2- 3
		1	*12	6½		2- 8
		¾	12	5¼		1-10½
5	2	1	13½	6¾	35.0	2- 6
		1	*15	8¼		3- 3
		¾	14	5¾		2- 1
6	2	1	14¾	6½	37.5	2- 4
		1	*16½	8¼		3- 2

SCREW ENDS FOR ADJUSTABLE BARS

Size of Bar: Width In.	Min. Thickness In.	Area In.²	Upset End: Dia. D In.	Lgth. T In.	Thds. per Inch	At Root of Thread: Diam. In.	Area In.²	Excess over Bar %	Add. Material B Ft. In.
	* ⅝	1.25	1¾	4	5	1.49	1.74	39.6	1- 0
2	¾	1.50	1⅞	4½	5	1.62	2.05	36.6	1- 0
	⅞	1.75	2	4½	4½	1.71	2.30	31.4	0-11
	* ¾	1.88	2⅛	4½	4½	1.84	2.65	41.2	1- 0
2½	⅞	2.19	2¼	5	4½	1.96	3.02	38.1	1- 0
	1	2.50	2⅜	5	4	2.09	3.42	36.7	1- 0
	* ¾	2.25	2¼	5	4½	1.96	3.02	34.3	1- 0
3	⅞	2.63	2½	5½	4	2.18	3.72	41.6	1- 1
	1	3.00	2½	5½	4	2.18	3.72	23.9	1- 1
	* ¾	3.00	2½	5½	4	2.18	3.72	23.9	1- 1
4	⅞	3.50	2¾	5½	4	2.43	4.62	32.0	0-11
	1	4.00	3	6	3½	2.63	5.43	35.7	1- 1
	1⅛	4.50	3¼	6½	3½	2.88	6.51	44.6	1- 2
	* ¾	3.75	2⅞	6	3½	2.55	5.11	36.2	1- 0
	⅞	4.38	3	6	3½	2.63	5.43	24.1	0-11
5	1	5.00	3¼	6½	3½	2.88	6.51	30.2	1- 0
	1⅛	5.63	3½	7	3¼	3.10	7.55	34.2	1- 1
	1¼	6.25	3¾	7	3	3.32	8.64	38.3	1- 2
	*1	6.00	3½	7	3¼	3.10	7.55	25.8	1- 0
6	1⅛	6.75	3¾	7	3	3.32	8.64	28.0	1- 0
	1¼	7.50	4	7½	3	3.57	9.99	33.2	1- 1
	1⅜	8.25	4¼	8	2⅞	3.80	11.3	37.3	1- 2

Pin holes to be deducted in estimating weight.
***Bars are special.**

UPSET SCREW ENDS FOR SQUARE BARS

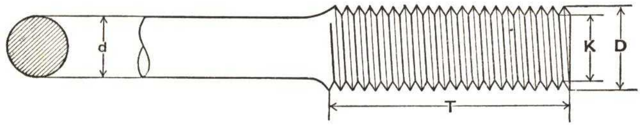


Thread: American Standard—Class 2 Fit

BAR			UPSET					
Side of Square d Inches	Area Sq. In.	Weight per Foot Lb.	Diameter D Inches	Length T Inches	Additional Length for Upset +10% Inches	Diameter at Root of Thread K Inches	Area At Root of Thread Sq. In.	Area Excess Over Area of Bar %
* ¾	0.563	1.91	1⅛	4	4	0.939	0.693	23.2
* ⅞	0.766	2.60	1¼	4	4	1.064	0.890	16.2
1	1.000	3.40	1½	4	4	1.283	1.294	29.4
1⅛	1.266	4.30	1⅝	4	3½	1.389	1.515	19.7
1¼	1.563	5.31	1⅞	4½	4½	1.615	2.049	31.1
1⅜	1.891	6.43	2	4½	4	1.711	2.300	21.7
1½	2.250	7.65	2¼	5	5	1.961	3.021	34.3
1⅝	2.641	8.98	2⅜	5	4½	2.086	3.419	29.5
1¾	3.063	10.41	2½	5½	4½	2.175	3.716	21.3
1⅞	3.516	11.95	2¾	5½	5	2.425	4.619	31.4
2	4.000	13.60	2⅞	6	5	2.550	5.108	27.7
2⅛	4.516	15.35	3	6	4½	2.629	5.428	20.2
2¼	5.063	17.21	3¼	6½	5½	2.879	6.509	28.6
2⅜	5.641	19.18	3½	7	6½	3.100	7.549	33.8
2½	6.250	21.25	3¾	7	7	3.317	8.641	38.3
2⅝	6.891	23.43	3¾	7	5½	3.317	8.641	25.4
2¾	7.563	25.71	4	7½	6½	3.567	9.993	32.1
2⅞	8.266	28.10	4¼	8	7½	3.798	11.330	37.1
3	9.000	30.60	4¼	8	6	3.798	11.330	25.9
3⅛	9.766	33.20	4½	8½	7	4.028	12.741	30.5
3¼	10.563	35.91	4¾	8½	7½	4.255	14.221	34.6

*Upsets are special.

UPSET SCREW ENDS FOR ROUND BARS

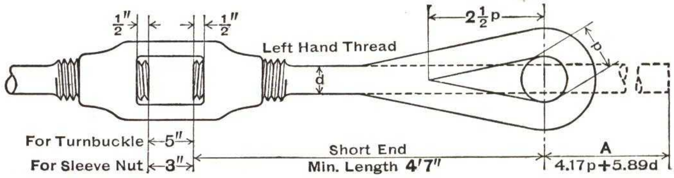


Thread: American Standard—Class 2 Fit

BAR			UPSET					
Diameter d Inches	Area Sq. In.	Weight per Foot Lb.	Diameter D Inches	Length T Inches	Additional Length for Upset +10% Inches	Diameter at Root of Thread K Inches	Area At Root of Thread Sq. In.	Area Excess Over Area of Bar %
* 3/4	0.442	1.50	1	4	5	0.838	0.551	24.7
* 7/8	0.601	2.04	1 1/4	4	5 1/2	1.064	0.890	48.0
1	0.785	2.67	1 3/8	4	4	1.158	1.054	34.2
1 1/8	0.994	3.38	1 1/2	4	4	1.283	1.294	30.2
1 1/4	1.227	4.17	1 5/8	4	4	1.389	1.515	23.5
1 3/8	1.485	5.05	1 3/4	4	4	1.490	1.744	17.5
1 1/2	1.767	6.01	2	4 1/2	4 1/2	1.711	2.300	30.2
1 5/8	2.074	7.05	2 1/8	4 1/2	4	1.836	2.649	27.7
1 3/4	2.405	8.18	2 1/4	5	4	1.961	3.021	25.6
1 7/8	2.761	9.39	2 3/8	5	4	2.086	3.419	23.8
2	3.142	10.68	2 1/2	5 1/2	4	2.175	3.716	18.3
2 1/8	3.547	12.06	2 5/8	5 1/2	3 1/2	2.300	4.156	17.2
2 1/4	3.976	13.52	2 7/8	6	4 1/2	2.550	5.108	28.4
2 3/8	4.430	15.06	3	6	4 1/2	2.629	5.428	22.5
2 1/2	4.909	16.69	3 1/4	6 1/2	5 1/2	2.879	6.509	32.6
2 5/8	5.412	18.40	3 1/4	6 1/2	4 1/2	2.879	6.509	20.3
2 3/4	5.940	20.19	3 1/2	7	5 1/2	3.100	7.549	27.1
2 7/8	6.492	22.07	3 3/4	7	6	3.317	8.641	33.1
3	7.069	24.03	3 3/4	7	5	3.317	8.641	22.2
3 1/8	7.670	26.08	4	7 1/2	6	3.567	9.993	30.3
3 1/4	8.296	28.21	4	7 1/2	5	3.567	9.993	20.5
3 3/8	8.946	30.42	4 1/4	8	5 1/2	3.798	11.330	26.6
3 1/2	9.621	32.71	4 1/4	8	5	3.798	11.330	17.8
3 5/8	10.321	35.09	4 1/2	8 1/2	5 1/2	4.028	12.741	23.4
3 3/4	11.045	37.55	4 3/4	8 1/2	6	4.255	14.221	28.8
3 7/8	11.793	40.10	4 3/4	8 1/2	5 1/2	4.255	14.221	20.6

*Upsets are special.

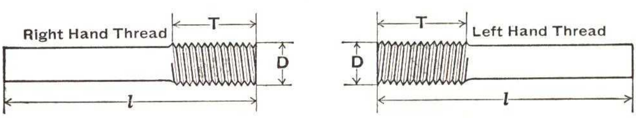
LOOP RODS AND STUB ENDS



Thread: American Standard—Class 2 Fit

Pin Diam. p Inches	LENGTH "A" FOR ONE LOOP IN FEET AND INCHES										
	Size of Square or Round Bar, d, in Inches										
	¾	⅞	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2
1⅛	0- 9½	0-10	0-11	0-11½							
1¼	0-10	0-10½	0-11½	1- 0	1- 1						
1½	0-11	0-11½	1- 0½	1- 1	1- 2	1- 2½					
1¾	1- 0	1- 0½	1- 1½	1- 2	1- 3	1- 3½	1- 4½	1- 5	1- 6		
2	1- 1	1- 1½	1- 2½	1- 3	1- 4	1- 4½	1- 5½	1- 6	1- 7	1- 7½	1- 8½
2¼	1- 2	1- 3	1- 3½	1- 4½	1- 5	1- 5½	1- 6½	1- 7	1- 8	1- 8½	1- 9½
2½	1- 3	1- 4	1- 4½	1- 5½	1- 6	1- 7	1- 7½	1- 8	1- 9	1- 9½	1-10½
2¾	1- 4	1- 5	1 -5½	1- 6½	1- 7	1- 8	1- 8½	1- 9½	1-10	1-11	1-11½
3	1- 5	1- 6	1- 6½	1- 7½	1- 8	1- 9	1- 9½	1-10½	1-11	2- 0	2- 0½
*3¼	1- 6	1- 7	1- 7½	1- 8½	1- 9	1-10	1-10½	1-11½	2- 0	2- 1	2- 1½
3½	1- 7½	1- 8	1- 8½	1- 9½	1-10	1-11	1-11½	2- 0½	2- 1	2- 2	2- 2½
*3¾	1- 8½	1- 9	1-10	1-10½	1-11	2- 0	2- 0½	2- 1½	2- 2	2- 3	2- 3½
4	1- 9½	1-10	1-11	1-11½	2- 0½	2- 1	2- 2	2- 2½	2- 3	2- 4	2- 4½
*4¼		1-11	2- 0	2- 0½	2- 1½	2- 2	2- 3	2- 3½	2- 4½	2- 5	2- 6
4½		2- 0	2- 1	2- 1½	2- 2½	2- 3	2- 4	2- 4½	2- 5½	2- 6	2 -7
*4¾		2- 1	2- 2	2- 2½	2- 3½	2- 4	2- 5	2- 5½	2- 6½	2- 7	2- 8
5		2- 2½	2- 3	2- 3½	2- 4½	2- 5	2- 6	2- 6½	2- 7½	2- 8	2- 9
*5¼			2- 4	2- 5	2- 5½	2- 6	2- 7	2- 7½	2- 8½	2- 9	2-10
5½			2- 5	2- 6	2- 6½	2- 7½	2- 8	2- 9	2- 9½	2-10	2-11
*5¾			2- 6	2- 7	2- 7½	2- 8½	2- 9	2-10	2-10½	2-11½	3- 0
6			2- 7	2- 8	2- 8½	2- 9½	2-10	2-11	2-11½	3- 0½	3- 1
*6¼				2- 9	2- 9½	2-10½	2-11	3- 0	3- 0½	3- 1½	3- 2
6½				2-10	2-10½	2-11½	3- 0	3- 1	3- 1½	3- 2½	3- 3
*6¾				2-11	3- 0	3- 0½	3- 1	3- 2	3- 2½	3- 3½	3- 4
7				3- 0	3- 1	3- 1½	3- 2½	3- 3	3- 3½	3- 4½	3- 5

*Pins are special. Maximum shipping length of long end = 35 feet.



Dia. of Round, In.	¾		⅞	1	1⅛	1¼	1⅜		1½	1⅝	1¾	1⅞	2
Side of Square, In.		¾	⅞		1	1⅛		1¼	1⅜		1½	1⅝	1¾
Dia. of Upset, D, In.	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2⅛	2¼	2⅜	2½
Length of Upset, T, In.	4	4	4	4	4	4	4	4½	4½	4½	5	5	5½
Length, l, In.	9½	9½	10	10½	10½	11	11½	11½	11½	11½	12	12½	13

PIPE

DIMENSIONS							COUPLINGS			PROPERTIES		
Nom. Dia. In.	Outside Dia. In.	Inside Dia. In.	Thick-ness In.	Weight per Foot Lb. Plain Ends	Weight per Foot Lb. Thread & Cplg.	Threads per Inch	Outside Dia. In.	Length In.	Weight Lb.	I In.^{4}	A In.^{2}	r In.
					STANDARD							
⅛	.405	.269	.068	.24	.25	27	.562	⅞	.03	.001	.072	.12
¼	.540	.364	.088	.42	.43	18	.685	1	.04	.003	.125	.16
⅜	.675	.493	.091	.57	.57	18	.848	1⅛	.07	.007	.167	.21
½	.840	.622	.109	.85	.85	14	1.024	1⅜	.12	.017	.250	.26
¾	1.050	.824	.113	1.13	1.13	14	1.281	1⅝	.21	.037	.333	.33
1	1.315	1.049	.133	1.68	1.68	11½	1.576	1⅞	.35	.087	.494	.42
1¼	1.660	1.380	.140	2.27	2.28	11½	1.950	2⅛	.55	.195	.669	.54
1½	1.900	1.610	.145	2.72	2.73	11½	2.218	2⅜	.76	.310	.799	.62
2	2.375	2.067	.154	3.65	3.68	11½	2.760	2⅝	1.23	.666	1.075	.79
2½	2.875	2.469	.203	5.79	5.82	8	3.276	2⅞	1.76	1.530	1.704	.95
3	3.500	3.068	.216	7.58	7.62	8	3.948	3⅛	2.55	3.017	2.228	1.16
3½	4.000	3.548	.226	9.11	9.20	8	4.591	3⅝	4.33	4.788	2.680	1.34
4	4.500	4.026	.237	10.79	10.89	8	5.091	3⅝	5.41	7.233	3.174	1.51
5	5.563	5.047	.258	14.62	14.81	8	6.296	4⅛	9.16	15.16	4.300	1.88
6	6.625	6.065	.280	18.97	19.19	8	7.358	4⅛	10.82	28.14	5.581	2.25
8	8.625	8.071	.277	24.70	25.00	8	9.420	4⅝	15.84	63.35	7.265	2.95
8	8.625	7.981	.322	28.55	28.81	8	9.420	4⅝	15.84	72.49	8.399	2.94
10	10.750	10.192	.279	31.20	32.00	8	11.721	6⅛	33.92	125.9	9.178	3.70
10	10.750	10.136	.307	34.24	35.00	8	11.721	6⅛	33.92	137.4	10.07	3.69
10	10.750	10.020	.365	40.48	41.13	8	11.721	6⅛	33.92	160.7	11.91	3.67
12	12.750	12.090	.330	43.77	45.00	8	13.958	6⅛	48.27	248.5	12.88	4.39
12	12.750	12.000	.375	49.56	50.71	8	13.958	6⅛	48.27	279.3	14.58	4.38
					EXTRA STRONG							
⅛	.405	.215	.095	.31	.32	27	.582	1⅛	.05	.001	.093	.11
¼	.540	.302	.119	.54	.54	18	.724	1⅜	.07	.004	.157	.15
⅜	.675	.423	.126	.74	.75	18	.898	1⅝	.13	.009	.217	.20
½	.840	.546	.147	1.09	1.10	14	1.085	1⅞	.22	.020	.320	.25
¾	1.050	.742	.154	1.47	1.49	14	1.316	2⅛	.33	.045	.433	.32
1	1.315	.957	.179	2.17	2.20	11½	1.575	2⅜	.47	.106	.639	.41
1¼	1.660	1.278	.191	3.00	3.05	11½	2.054	2⅞	1.04	.242	.881	.52
1½	1.900	1.500	.200	3.63	3.69	11½	2.294	2⅞	1.17	.391	1.068	.61
2	2.375	1.939	.218	5.02	5.13	11½	2.870	3⅝	2.17	.868	1.477	.77
2½	2.875	2.323	.276	7.66	7.83	8	3.389	4⅛	3.43	1.924	2.254	.92
3	3.500	2.900	.300	10.25	10.46	8	4.014	4⅛	4.13	3.894	3.016	1.14
3½	4.000	3.364	.318	12.51	12.82	8	4.628	4⅝	6.29	6.280	3.678	1.31
4	4.500	3.826	.337	14.98	15.39	8	5.233	4⅝	8.16	9.610	4.407	1.48
5	5.563	4.813	.375	20.78	21.42	8	6.420	5⅛	12.87	20.67	6.112	1.84
6	6.625	5.761	.432	28.57	29.33	8	7.482	5⅛	15.18	40.49	8.405	2.20
8	8.625	7.625	.500	43.39	44.72	8	9.596	6⅛	26.63	105.7	12.76	2.88
10	10.750	9.750	.500	54.74	56.94	8	11.958	6⅝	44.16	211.9	16.10	3.63
12	12.750	11.750	.500	65.42	68.02	8	13.958	6⅝	51.99	361.5	19.24	4.34
					DOUBLE—EXTRA STRONG							
½	.840	.252	.294	1.71	1.73	14	1.085	1⅞	.22	.024	.504	.22
¾	1.050	.434	.308	2.44	2.46	14	1.316	2⅛	.33	.058	.718	.28
1	1.315	.599	.358	3.66	3.68	11½	1.575	2⅜	.47	.140	1.076	.36
1¼	1.660	.896	.382	5.21	5.27	11½	2.054	2⅞	1.04	.341	1.534	.47
1½	1.900	1.100	.400	6.41	6.47	11½	2.294	2⅞	1.17	.568	1.885	.55
2	2.375	1.503	.436	9.03	9.14	11½	2.870	3⅝	2.17	1.311	2.656	.70
2½	2.875	1.771	.552	13.70	13.87	8	3.389	4⅛	3.43	2.871	4.028	.84
3	3.500	2.300	.600	18.58	18.79	8	4.014	4⅛	4.13	5.992	5.466	1.05
3½	4.000	2.728	.636	22.85	23.16	8	4.628	4⅝	6.29	9.848	6.721	1.21
4	4.500	3.152	.674	27.54	27.95	8	5.233	4⅝	8.16	15.28	8.101	1.37
5	5.563	4.063	.750	38.55	39.20	8	6.420	5⅛	12.87	33.64	11.34	1.72
6	6.625	4.897	.864	53.16	53.92	8	7.482	5⅛	15.18	66.33	15.64	2.06
8	8.625	6.875	.875	72.42	73.76	8	9.596	6⅛	26.63	162.0	21.30	2.76

LARGE O. D. PIPE

Pipe 14″ and larger is sold by actual O. S. diameter and thickness.
Sizes, 14″, 15″, and 16″ are available regularly in thicknesses varying by 1/16″ from ¼″ to 1″, inclusive.

All pipe is furnished random length unless otherwise ordered, viz: 12 to 22 feet with privilege of furnishing 5 per cent in 6 to 12 feet lengths. Pipe railing is most economically detailed with slip joints and random lengths between couplings.

MALLEABLE IRON PIPE RAILING FITTINGS

SEE NOTE ON PAGE 158

CAST IRON FITTINGS FOR PIPE RAILING

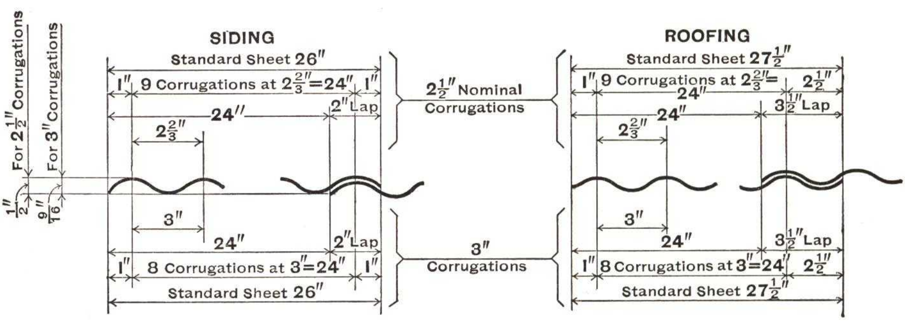
SEE NOTE ON PAGE 158

CORRUGATED SHEET METAL CONSTRUCTION

Corrugated steel, in addition to its extensive application as roofing and siding for buildings, is adaptable to other varied requirements such as lining of shafts, supports and forms for floor arches, partitions, enclosures and culverts.

Corrugated sheets are available in steel of regular analysis or in rust-resisting alloys, usually copper-bearing steel, either black (unpainted mill finish), painted or galvanized. Although the mills offer a wide choice in types and widths of corrugations, the curved type illustrated below is generally used. Standard lengths range from 60 inches to a maximum of 144 inches varying by 12 inches. Other lengths are available but subject to an extra charge.

DATA FOR ESTIMATING ROOFING AND SIDING



Corrugations: Nominal 2½ inches (actual 2⅔ inches), is preferred for domestic work, and 3 inch for export.

Roofing sheet is 27½ inches wide after corrugating and has one edge turned up and the other down. It is laid with a side lap of 1½ corrugations (covering approximately 24 inches net width) and a minimum end lap of 6 inches for roof pitch of 4 inches in 12 inches or over. For roofs under 4 inch pitch the minimum end lap should be 8 inches.

Corrugated steel roofing is seldom used for roof pitch under 3 inches in 12 inches.

Siding sheet is 26 inches wide after corrugating and has both edges of sheet turned the same way. It is laid with a side lap of one corrugation (covering approximately 24 inches net width) and a minimum end lap of 4 inches.

For export work, corrugated sheets are frequently furnished with 3 inch corrugations and in 32 inch width, covering 27 inches net when laid with 2 corrugations side lap for roofing, and 30 inches net with one corrugation side lap for siding; also in 33½ inch width, covering 30 inches net with 1½ corrugations side lap, for roofing and siding.

Sheet steel flashing must be provided at roof ridge, eaves, windows and wherever necessary to insure watertight results.

The following approximate method of obtaining the gross area required may be used:

Roofing = Net area + end laps + 15% for side laps of 1½ corrugations.
Siding = Net area + end laps + 10% for side laps of 1 corrugation.

CORRUGATED SHEET METAL CONSTRUCTION

U. S. Manufacturers Standard Gage	Thickness Inches (Black)	Permissible Variation + or — % of Wt.	Flat Sheets Pounds per Sq. Ft.		2½″ and 3″ Corrugations					
					26″ Sheets Pounds per Sq. Ft.		27½″ Sheets Pounds per Sq. Ft.		Maximum Span Between Supports	
			Galv.	Black	Galv.	Black	Galv.	Black	Roofing	Siding
12	.105	3.5	4.53	4.38	4.88	4.71	4.94	4.77	5′9″	5′10″
14	.075	3.5	3.28	3.13	3.53	3.37	3.58	3.41	5′9″	5′10″
16	.060	3.5	2.66	2.50	2.86	2.69	2.90	2.73	5′9″	5′10″
18	.048	3.5	2.16	2.00	2.32	2.15	2.35	2.18	5′9″	5′10″
20	.036	2.5	1.66	1.50	1.78	1.62	1.81	1.64	5′9″	5′10″
21	.033	2.5	1.53	1.38	1.65	1.48	1.67	1.50	5′9″	5′10″
22	.030	2.5	1.41	1.25	1.51	1.35	1.53	1.36	4′9″	5′10″
23	.027	2.5	1.28	1.13	1.38	1.21	1.40	1.23	4′9″	5′10″
24	.024	2.5	1.16	1.00	1.25	1.08	1.26	1.09	3′9″	4′10″
25	.021	2.5	1.03	.88	1.11	.94	1.13	.96	3′9″	4′10″
26	.018	2.5	.91	.75	.98	.81	.99	.82	2′9″	3′10″
28	.015	2.5	.78	.63	.84	.67	.85	.68	2′9″	3′10″

To obtain the weight of black painted sheets, add 0.01 lb. per sq. ft. to weight of black sheets.

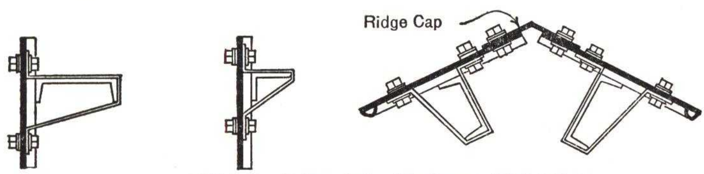
Corrugated metal for export work is sometimes specified to Birmingham (B.G.) gage.

Permissible variations apply to weight of steel sheets ordered by weight or gage number, in lots of 20 tons and over. For further details of permissible variations see American Iron and Steel Institute Manual, Section 11.

FASTENINGS FOR CORRUGATED STEEL

Umbrella Head Clinch Rivet
Maximum Length 15½″

Clinch rivets shown above are frequently used where high winds are not anticipated. Closing rivets, 3/16″ dia. and driven cold, are used for riveting side and end laps.



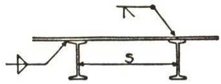
¼″ Galv. Bolts; Galv. Washers with Lead or Asphalt Saturated Felt Washers underneath
18 Ga. Galv. Metal Straps, 1″ wide.

In most localities, the strap fastenings shown above are a required standard.

A fastening now gaining in favor comprises a No. 14 Hex. Head self-tapping Cap Screw, applied wholly from outside the structure; with a soft lead washer against the sheet and a steel washer under the head of the screw.

BATTLEDECK FLOOR

SIMPLE-SPAN CONSTRUCTION



STANDARD I-BEAMS

MAXIMUM STRINGER UNIT STRESS 18000 PSI. MAX. L. L. DEFLECTION $\frac{\text{SPAN}}{500}$

DEAD LOAD INCLUDES 1.1 LB./SQ. FT. FOR BITUMINOUS SURFACING

RECOMMENDED STRINGER SIZES

S	Plate Th'k-ness	Live Load	Span Length c. to c. of Bearings, in Feet											
In.	In.	⊕	14	16	18	20	22	24	26	28	30	32	34	36
10	3/8	H-15	8I18.4	8I18.4	8I18.4	8I18.4	8I23	10I25.4	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8
	3/8	H-20	8I18.4	8I18.4	8I23	10I25.4	10I25.4	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I40.8	15I42.9
12	7/16	H-15	8I18.4	8I18.4	8I18.4	8I18.4	8I23	10I25.4	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8
	7/16	H-20	8I18.4	8I23	8I23	10I25.4	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I40.8	15I42.9
14	1/2	H-15	8I18.4	8I18.4	8I18.4	8I23	10I25.4	10I25.4	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I35
	1/2	H-20	8I18.4	8I23	10I25.4	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I35	15I42.9*	15I42.9*
16	1/2	H-15	8I18.4†	8I18.4†	8I23 †	10I25.4†	10I25.4†	10I25.4†	10I25.4†	12I31.8	12I31.8	12I31.8	12I31.8	12I40.8
	1/2	H-20	8I23 †	10I25.4†	10I25.4†	10I25.4†	12I31.8	12I31.8	12I31.8	12I31.8	12I35	12I40.8	15I42.9	15I42.9
18	9/16	H-15	8I18.4	8I23	8I23	10I25.4	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I35	12I40.8
	9/16	H-20	8I23	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I35	12I40.8	12I40.8	15I42.9	15I42.9
20	5/8	H-15	8I18.4	8I23	10I25.4	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I31.8	12I40.8	15I42.9
	5/8	H-20	10I25.4	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I40.8	12I40.8	15I42.9	15I42.9	15I42.9
22	5/8	H-15	8I23 †	10I25.4	10I25.4	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I40.8	12I40.8	15I42.9
	5/8	H-20	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I35	12I40.8	15I42.9	15I42.9	15I42.9	15I42.9
24	11/16	H-15	8I23	10I25.4	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I35	12I40.8	15I42.9	15I42.9
	11/16	H-20	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I35	12I40.8	15I42.9	15I42.9	15I42.9	15I42.9	15I50
26	11/16	H-15	10I25.4	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I35	12I40.8	12I40.8	15I42.9	15I42.9
	11/16	H-20	10I25.4†	12I31.8	12I31.8	12I31.8	12I35	12I40.8	12I40.8	15I42.9	15I42.9	15I42.9	15I50	18I54.7
28	11/16	H-15	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I35	12I40.8	12I40.8	15I42.9	15I42.9	15I42.9
	3/4	H-20	10I25.4	12I31.8	12I31.8	12I31.8	12I40.8	12I40.8	15I42.9	15I42.9	15I42.9	15I50	18I54.7	18I54.7
30	3/4	H-15	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I31.8	12I35	15I42.9*	15I42.9*	15I42.9*	15I42.9*	15I50 *
	3/4	H-20	12I31.8	12I31.8	12I31.8	12I35	12I40.8	15I42.9	15I42.9	15I42.9	15I50	15I50	18I54.7	18I54.7
32	3/4	H-15	10I25.4	10I25.4	12I31.8	12I31.8	12I31.8	12I35	12I40.8	15I42.9	15I42.9	15I42.9	15I42.9	15I50
	3/4	H-20	12I31.8	12I31.8†	12I31.8†	15I42.9	15I42.9	15I42.9	15I42.9	15I42.9	15I50	18I54.7	18I54.7	18I54.7

⊕As defined by American Association of State Highway Officials.

*Plate thickness 1/16″ less than stated. † Plate thickness 1/16″ more than stated.

The foregoing table is adapted from one of the several tables contained in the A. I. S. C. pamphlet "The Battledeck Floor for Highway Bridges."

Various applications of this type of floor construction, shop or field welded, with or without bituminous surfacing, and for use on short or long spans, are discussed in the pamphlet, together with semi-rational design rules based upon research with full-scale models.

PART II

ESTIMATING AND DETAILING INFORMATION

This part contains such data on details and weights as will be useful in preparation of estimates and detail drawings, and have not already appeared in Part I.

DETAILING PRACTICE

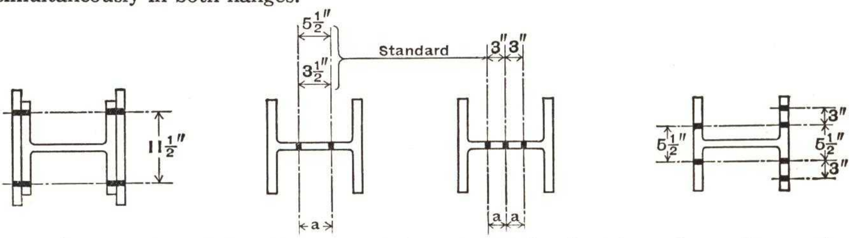
Maximum efficiency in the fabrication of structural steel by modern shops is entirely dependent upon close cooperation between designing office, drafting room and shop. Designs should be favorable to, the drafting room should recognize and call for, and the shop should adapt its equipment to, the use of recurrent details which have been standardized.

Consideration should be given to duplication of details and multiple punching or drilling. Utilization of standard jigs and machine set-ups eliminates unnecessary handling of material and aids drilling or punching holes in groups.

Column gage lines should conform to the standard machine set-ups illustrated below. Once determined they should be duplicated as far as possible throughout any one job. Gages on an individual member should not be varied throughout the length of that member.

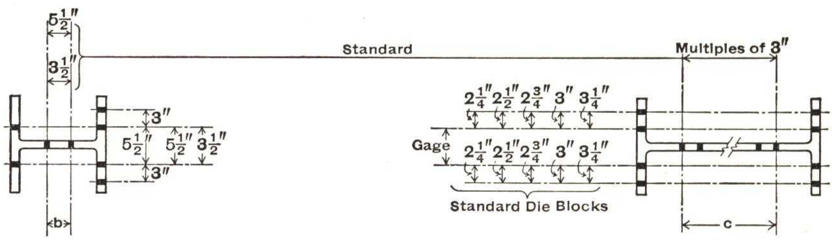
DRILL GAGES

Keep gages and longitudinal spacing alike, if possible, as drilling can be done simultaneously in both flanges.



Minimum "a" = 3", Maximum "a" controlled by size of member. Gages other than standard should be multiples of 3".

PUNCH GAGES



Minimum "b" = 2¼", Maximum "b" controlled by size of member. Gages other than standard should be multiples of 3". Maximum "c" controlled by size of member.

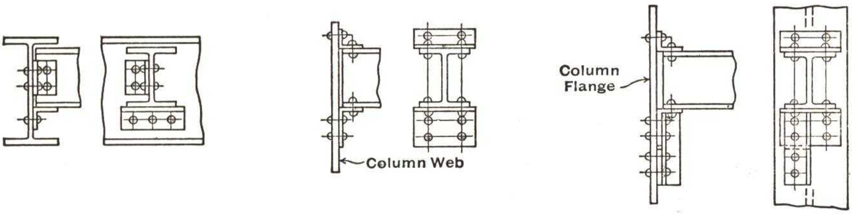
Longitudinal spacing of holes for both punched and drilled work should be 3" or multiples of 3". The adoption of such spacing facilitates the use of multiple drills and punches and makes possible the use of the Standard Beam Connections detailed on pages 151 and 153.

In general the principles governing the selection of gages and longitudinal spacing of holes in beam webs and flanges are identical with those for columns. Sketches and notes for "Punch Gages" apply to all sections. Minimum gages are tabulated under "Dimensions for Detailing;" pages 13 to 31. See page 156 for information and dimensions pertaining to clearance requirements.

Beams are connected to columns or other beams by framing angles or they are seated. The need of providing for wind or other bending moments may require a combination of the two. Typical examples of seated and windbracing connections are illustrated on the opposite page.

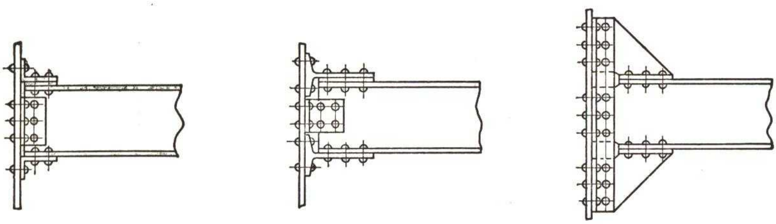
Standard Beam Connections (A, H, HH, B, K and KK Series) should be used wherever suitable; special heavy connections, pages 260 and 261, should be used only when the capacities of Standard Connections are exceeded. Single angle connections should be used only where construction details prevent the use of standard connections.

SEATED CONNECTIONS



Seated connections without stiffener angles may be used for the values of end reactions up to 35 kips given in the table on page 263. Seated connections with single or double stiffeners are used for values of end reactions given in the table on page 262 or for beams over 18″ in depth. It should be noted that the rivets in the vertical leg determine the capacity of the connection.

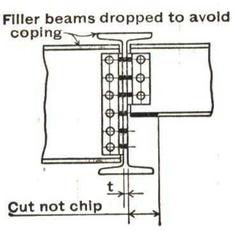
WIND BRACING CONNECTIONS



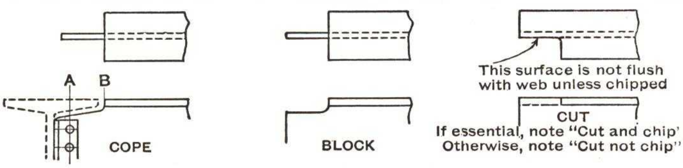
Wind bracing connections, or connections designed to resist bending moments, are usually made with angles or split beams. Brackets are frequently used where architectural features and clearances permit.

It is essential, for erection purposes, that sufficient clearance be provided between the top angle and top of beam for all seated connections. For top angles riveted to the column allow ¼″ and provide two ⅛″ fills; if the angle is to be shipped loose provide ⅛″ clearance with no fills. To insure web holes matching, beam details should be dimensioned from the bottom flange. Always work with the actual depth of beams, never the nominal.

Where flanges interfere they must be cut as shown to allow insertion of field rivets or bolts.



See pages 254 and 258 for method of calculating value of connections for beams framing opposite.



These sketches indicate standard methods of providing clearance for beams connecting to beams or columns. Where possible, a minimum clearance of ½″ is to be provided. Consult fabricator for dimension list of his standard copes and blocks.

Coping or blocking of beams should be avoided wherever possible. When construction will permit, the elevation of the top of filler beams should be established a sufficient distance below the top of girders to clear the thickest girder flange. Unusually long or deep copes and blocks, or blocks in beams with thin webs, may materially affect the capacity of the beam. Such beams must be investigated for both shear and moment at lines A and B and, when necessary, adequate reinforcement provided. Some fabricators designate all the operations pictured above by the term "Cuts."

For weights of standard connections and minimum spans to which applicable, see pages 150 to 153.
For allowable loads on standard connections, see pages 252 to 259.
For methods of calculating special connections and for detail of one sided connections, see pages 260 and 261.

RIVETS

7/8″

STANDARD BEAM CONNECTIONS

WIDE FLANGE BEAMS

WEIGHTS AND MINIMUM SPANS
FOR ALLOWABLE UNIFORM LOADS

Entering this table with size of beam, the symbols and weights of Standard "A", "H" and "HH" Connections are found, together with the minimum spans for which they are respectively sufficient. Information for "H" Connections has been omitted in the tables where shear in rivets in outstanding legs governs and, therefore, permit the same values as "A" Connections. Standard "A", "H" and "HH" Connections are for use with 7/8″ rivets, and are detailed on page 151.

More general information on capacity of any connection, Standard or Special, will be found on pages 252 to 264.

Weights include shop (web) rivets only.

Section		"A" Connection			"H" Connection			"HH" Connection		
Depth	Wt. Lb.	Symbol	Wt. Lb.	Min. Span Feet	Symbol	Wt. Lb.	Min. Span Feet	Sym-bol	Wt. Lb.	Min. Span Feet
36	300			40.8						25.5
	280			38.1						23.8
	260			35.1						22.0
	245			33.0						20.6
	230	A 10	62	30.9				HH 10	101	19.3
	194			24.5						15.3
	182			23.0						14.3
	170			21.4						13.4
	160			20.0						12.5
	150			18.6						11.6
33	240			33.3						21.4
	220			30.4						19.5
	200	A 9	56	27.5				HH 9	90	17.7
	152			20.0						12.8
	141			18.3						11.8
	130			16.6						10.8†
30	210			30.0						20.0
	190			27.1						18.0
	172	A 8	50	24.4				HH 8	79	16.3
	132			17.5						11.7
	124			16.4						10.9
	116			15.1						10.1
	108			13.8						9.4†
27	177			26.0						16.6
	160			23.4						14.9
	145	A 7	43	21.3	H 7	60		HH 7	70	13.5
	114			15.8						10.1
	102			14.1						9.7†
	94			13.5†			12.8			9.4†
24	160			25.5						15.3
	145			23.0						13.8
	130			20.4						12.4†
	120			18.4						11.4†
	110	A 6	37	17.1†	H 6	52	16.9	HH 6	60	11.4†
	100			16.9†			15.3			11.4†
	94			13.6†			13.6			9.0†
	84			13.3†			12.1			8.9†
	76			12.7†			10.8			8.6†

Section		"A" Connection			"H" Connection			"HH" Connection		
Depth	Wt. Lb.	Symbol	Wt. Lb.	Min. Span Feet	Symbol	Wt. Lb.	Min. Span Feet	Sym-bol	Wt. Lb.	Min. Span Feet
21	142			23.4						14.7
	127			21.0						13.1
	112			18.4						11.6†
	96	A 5	31	14.6	H 5	43		HH 5	50	9.1
	82			12.8†			12.4			8.3†
	73			12.6†			11.1			8.0†
	68			12.4†			10.3			7.9†
	62			12.0†			9.4			7.7†
18	114			20.3						10.3†
	105			18.7						10.2†
	96			17.2†			17.0			10.2†
	85			14.4†			14.4			8.3†
	77	A 4	22	14.2†	H 4	32	13.1	HH 4	37	8.4†
	70			13.9†			11.8			8.3†
	64			13.8†			10.8			8.3†
	60			12.3†			10.0			7.4†
	55			12.0†			9.1			7.1†
	50			11.8†			8.2			7.1†
16	96			15.3						9.8†
	88			14.3†			14.0			9.5†
	78			11.8†			11.8			7.6†
	71	A 4	22	11.4†	H 4	32	10.7	HH 4	37	7.6†
	64			11.2†			9.6			7.5†
	58			11.0†			8.7			7.5†
	50			10.1†			7.5			6.7†
	45			10.0†			6.7			6.7†
	40			10.0†			6.7†			6.7†
	36			9.0†			6.1†			6.1†
14	38	A 3	16	11.1†	H 3	24	6.7	HH 3	27	6.3†
	34			10.7†			6.2†			6.2†
	30			9.8†			5.7†			5.7†
12	36			9.6†			6.3†			
	31	A 3	16	9.4†	H 3	24	6.3†			
	27			9.0†			6.1†			
10	29			5.7						
	25	A 2	16	5.3†						
	21			4.6†						
8	20			4.3†						
	17	A 2	16	3.9†						

†These spans are governed by web bearing or web shear

RIVETS $\frac{7}{8}''$

STANDARD BEAM CONNECTIONS

AMERICAN STANDARD BEAMS

WEIGHTS AND MINIMUM SPANS FOR ALLOWABLE UNIFORM LOADS

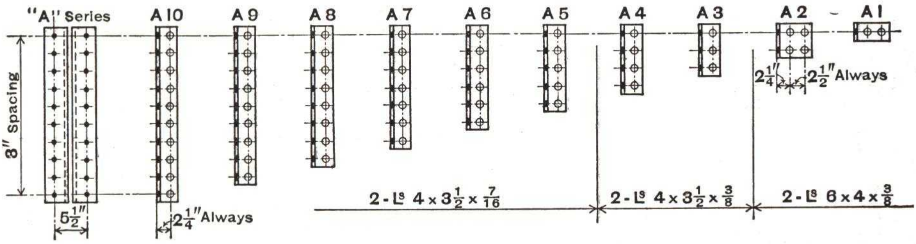
Notes on page 150 apply in general.
For Channels use same standard connection as for American Standard Beam of same depth.

Section		"A" Connection			"H" Connection			"HH" Connection		
Depth In.	Wt. Lb.	Symbol	Wt. Lb.	Min. Span Feet	Symbol	Wt. Lb.	Min. Span Feet	Sym-bol	Wt. Lb.	Min. Span Feet
24	120			15.5						9.3
	105.9			14.4						8.7
	100	A 6	37	12.2	H 6	52		HH 6	60	7.3
	90			11.4						6.9
	79.9			11.0†			10.7			7.4†
20	95			11.8						7.4
	85	A 5	31	11.1	H 5	43		HH 5	50	6.9
	75			9.3						5.8
	65.4			8.9†			8.6			6.1†
18	70	A 4	22	9.4	H 4	32		HH 4	37	4.7
	54.7			9.2†			8.2			5.5†
15	50			5.9						4.0†
	42.9	A 4	22	6.8†	H 4	32	5.4	HH 4	37	4.9†

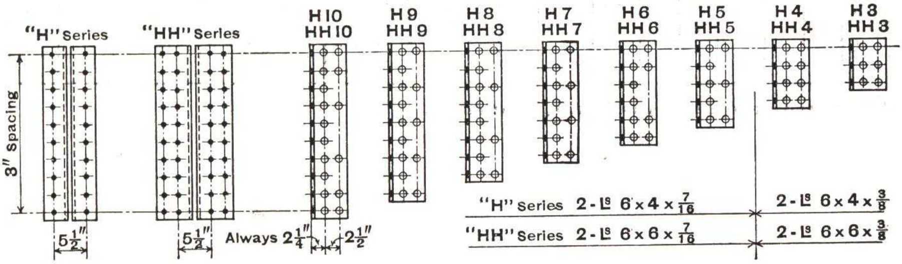
Section		"A" Connection			"H" Connection			"HH" Connection		
Depth In.	Wt. Lb.	Symbol	Wt. Lb.	Min. Span Feet	Symbol	Wt. Lb.	Min. Span Feet	Sym-bol	Wt. Lb.	Min. Span Feet
12	50			6.2			6.2			3.1†
	40.8	A 3	16	6.2†	H 3	24	5.5	HH 3	27	4.1†
	35			5.6†			4.7			3.8†
	31.8			6.5†			4.4			4.4†
10	35	A 2	16	5.4						
	25.4			4.5						
8	23	A 2	16	3.0						
	18.4			3.4†						
7	20	A 1	8	4.4						
	15.3			4.0†						
6	17.25	A 1	8	3.2						
	12.5			3.0†						
5	14.75	A 1	8	2.2						
	10			2.3†						

†These spans are governed by web bearing or web shear.

STANDARD TWO-ANGLE CONNECTIONS "A" SERIES



STANDARD TWO-ANGLE CONNECTIONS "H" AND "HH" SERIES



RIVETS
$\frac{3}{4}''$

STANDARD BEAM CONNECTIONS

WIDE FLANGE BEAMS

WEIGHTS AND MINIMUM SPANS FOR ALLOWABLE UNIFORM LOADS

Entering this table with size of beam, the symbols and weights of Standard "B", "K" and "KK" Connections are found, together with the minimum spans for which they are respectively sufficient. Information for "K" Connections has been omitted in the tables where shear in rivets in outstanding legs governs and, therefore, permit the same values as "B" Connections. Standard "B", "K" and "KK" Connections are for use with ¾" rivets and are detailed on page 153.

More general information on capacity of any connection, Standard or Special, will be found on pages 252 to 264.

Weights include shop (web) rivets only.

Section		"B" Connection			"K" Connection			"KK" Connection		
Depth	Wt. Lb.	Symbol	Wt. Lb.	Min. Span Feet	Symbol	Wt. Lb.	Min. Span Feet	Sym-bol	Wt. Lb.	Min. Span Feet
36	300			55.6						34.7
	280			51.9						32.4
	260			47.9						29.9
	245			45.0						28.0
	230	B 10	57	42.1				KK 10	93	26.3
	194			33.4						20.9
	182			31.3						19.5
	170			29.2						18.2
	160			27.2						17.0
	150			25.3						15.8
33	240			45.3						29.1
	220			41.4						26.6
	200	B 9	51	37.4				KK 9	83	24.1
	152			27.2						17.5
	141			25.0						16.0
	130			22.6						14.6
30	210			40.9						27.3
	190			36.9						24.6
	172	B 8	46	33.2				KK 8	73	22.1
	132			23.9						15.9
	124			22.3						14.9
	116			20.6						13.7
	108			18.8						12.5
27	177			35.4						22.5
	160			31.9						20.3
	145	B 7	40	29.0				KK 7	64	18.4
	114			21.5						13.7
	102			19.2						12.2
	94			17.5						11.1
24	160			34.7						20.8
	145			31.3						18.8
	130			27.7						16.6
	120			25.1						15.0
	110	B 6	34	23.0	K 6	47		KK 6	55	13.8
	100			20.9						12.5
	94			18.5						11.1
	84			16.5						9.9
	76			14.8†			14.7			8.9†

Section		"B" Connection			"K" Connection			"KK" Connection		
Depth	Wt. Lb.	Symbol	Wt. Lb.	Min. Span Feet	Symbol	Wt. Lb.	Min. Span Feet	Sym-bol	Wt. Lb.	Min. Span Feet
21	142			31.9						20.0
	127			28.6						17.9
	112			25.1						15.7
	96	B 5	28	19.9	K 5	39		KK 5	46	12.4
	82			16.9						10.6
	73			15.2						9.5
	68			14.5†			14.1			9.0†
	62			14.0†			12.7			8.8†
18	114			27.7						13.8
	105			25.4						12.7
	96			23.2						11.6
	85			19.6						9.8
	77	B 4	20	17.8	K 4	28		KK 4	33	8.9
	70			16.3†			16.1			8.3†
	64			16.1†			14.7			8.3†
	60			14.4†			13.5			7.4†
	55			14.0†			12.4			7.1†
	50			13.8†			11.2			7.1†
16	96			20.9						10.4
	88			19.0						9.5†
	78			16.1						8.0
	71	B 4	20	14.6	K 4	28		KK 4	33	7.6†
	64			13.1						7.5†
	58			12.9†			11.8			7.5†
	50			11.8†			10.2			6.7†
	45			11.6†			9.1			6.7†
	40			11.7†			8.1			6.7†
	36			10.5†			7.1			6.1†
14	38	B 3	14	12.9†	K 3	20	9.1	KK 3	24	6.5†
	34			12.5†			8.1			6.3†
	30			11.5†			7.0			5.7†
12	36			11.1†			7.7			
	31	B 3	14	11.0†	K 3	20	6.6			
	27			10.5†			6.1†			
10	29			7.8						
	25	B 2	13	6.7						
	21			5.4						
8	20	B 2	13	4.3						
	17			3.9†						

†These spans are governed by web bearing or web shear.

RIVETS $\frac{3}{4}''$

STANDARD BEAM CONNECTIONS

AMERICAN STANDARD BEAMS

WEIGHTS AND MINIMUM SPANS FOR ALLOWABLE UNIFORM LOADS

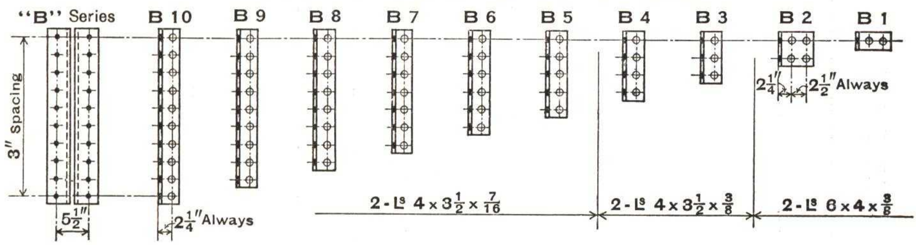
Notes on page 152 apply in general.
For Channels use same standard connection as for American Standard Beam of same depth.

Section		"B" Connection			"K" Connection			"KK" Connection		
Depth In.	Wt. Lb.	Symbol	Wt. Lb.	Min. Span Feet	Symbol	Wt. Lb.	Min. Span Feet	Sym-bol	Wt. Lb.	Min. Span Feet
24	120 105.9 100 90 79.9	B 6	34	21.1 19.7 16.6 15.6 14.6				KK 6	55	12.6 11.8 9.9 9.3 8.8
20	95 85 75 65.4	B 5	28	16.1 15.1 12.7 11.8				KK 5	46	10.1 9.4 7.9 7.4
18	70 54.7	B 4	20	12.8 11.1				KK 4	33	6.4 5.6
15	50 42.9	B 4	20	8.1 8.0†	K 4	28	 7.4	KK 4	33	4.0 4.9†

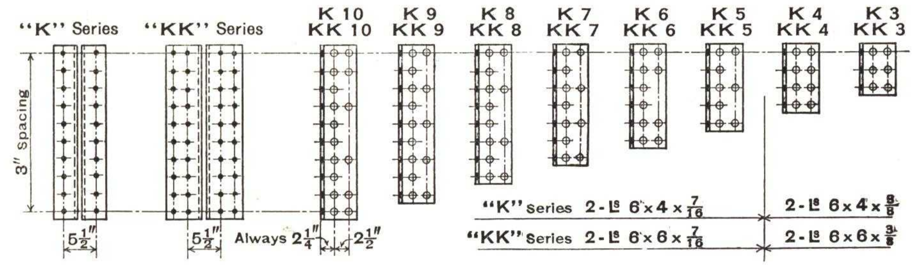
Section		"B" Connection			"K" Connection			"KK" Connection		
Depth In.	Wt. Lb.	Symbol	Wt. Lb.	Min. Span Feet	Symbol	Wt. Lb.	Min. Span Feet	Sym-bol	Wt. Lb.	Min. Span Feet
12	50 40.8 35 31.8	B 3	14	8.4 7.5 6.5† 7.6†	K 3	20	 6.3 6.0	KK 3	24	4.2 4.1† 3.8† 4.4†
10	35 25.4	B 2	13	7.3 6.1						
8	23 18.4	B 2	13	4.0 3.6						
7	20 15.3	B 1	7	6.0 5.2						
6	17.25 12.5	B 1	7	4.4 3.7						
5	14.75 10	B 1	7	3.0 2.5						

†These spans are governed by web bearing or web shear.

STANDARD TWO-ANGLE CONNECTIONS "B" SERIES



STANDARD TWO-ANGLE CONNECTIONS "K" AND "KK" SERIES



SEATED CONNECTIONS

MAXIMUM REACTIONS AND MINIMUM SPANS FOR ALLOWABLE UNIFORM LOADS

Seated connections without stiffener angles may be used for the values of end reactions up to 35 kips given in the table on page 263. Seated connections with single or double stiffeners are used for values of end reactions given in the table on page 262 or for beams over 18″ in depth.

WF Section		3½ In. Bearing		5½ In. Bearing	
Depth	Wt. Lb.	Max. React. Kips	Min. Span Feet	Max. React. Kips	Min. Span Feet
36	300	143	51.5	188	39.2
	280	132	52.1	174	39.5
	260	123	51.6	164	38.7
	245	114	52.2	152	39.2
	230	108	51.6	145	38.4
	194	104	42.5	141	31.4
	182	97	42.7	132	31.4
	170	89	43.4	122	31.6
	160	84	42.9	115	31.4
	150	80	42.0	110	30.5
33	240	118	45.8	158	34.2
	220	108	45.7	145	34.1
	200	98	45.6	132	33.8
	152	82	39.5	112	29.0
	141	76	39.2	105	28.4
	130	72	37.5	100	27.0
30	210	108	40.1	145	29.9
	190	97	40.3	131	29.8
	172	87	40.5	118	29.8
	132	77	32.9	107	23.7
	124	72	32.8	100	23.6
	116	69	31.7	96	22.8
	108	66	30.2	92	21.7
27	177	98	33.5	133	24.7
	160	88	33.6	120	24.7
	145	78	34.4	107	25.1
	114	70	28.5	97	20.6
	102	63	28.2	88	20.2
	94	58	28.0	82	19.8
24	160	87	31.7	118	23.4
	145	78	31.9	107	23.3
	130	71	31.1	98	22.5
	120	69	28.9	96	20.8
	110	63	29.0	87	21.0
	100	57	29.1	79	21.0
	94	61	24.1	86	17.1
	84	55	23.8	78	16.8
	76	50	23.4	71	16.5

WF Section		3½ In. Bearing		5½ In. Bearing	
Depth	Wt. Lb.	Max. React. Kips	Min. Span Feet	Max. React. Kips	Min. Span Feet
21	142	85	24.9	117	18.1
	127	74	25.6	102	18.6
	112	65	25.6	90	18.5
	96	70	18.8	98	13.4
	82	59	19.0	83	13.5
	73	53	19.0	75	13.4
	68	49	19.0	70	13.3
	62	45	18.8	64	13.2
18	114	74	19.8	103	14.2
	105	68	19.8	95	14.2
	96	62	19.8	87	14.1
	85	63	16.5	88	11.8
	77	56	16.9	79	12.0
	70	51	16.8	72	11.9
	64	46	17.0	65	12.0
	60	47	15.3	67	10.8
	55	43	15.2	62	10.6
	50	39	15.2	56	10.6
16	96	66	16.8	92	12.0
	88	61	16.5	85	11.9
	78	64	13.3	89	9.6
	71	57	13.6	80	9.7
	64	51	13.6	72	9.6
	58	46	13.6	66	9.5
	50	42	12.8	60	9.0
	45	38	12.7	55	8.8
	40	33	13.0	48	8.9
	36	32	11.7	46	8.2
14	38	34	10.7	49	7.4
	34	31	10.4	45	7.2
	30	28	10.0	41	6.8
12	36	33	9.3	48	6.4
	31	28	9.4	41	6.4
	27	25	9.1	36	6.4
10	29	30	6.8	38†	5.4†
	25	26	6.8	33†	5.4†
	21	24	6.0	31†	4.6†
8	20	25	4.6	26†	4.4†
	17	23	4.1	24†	3.9†

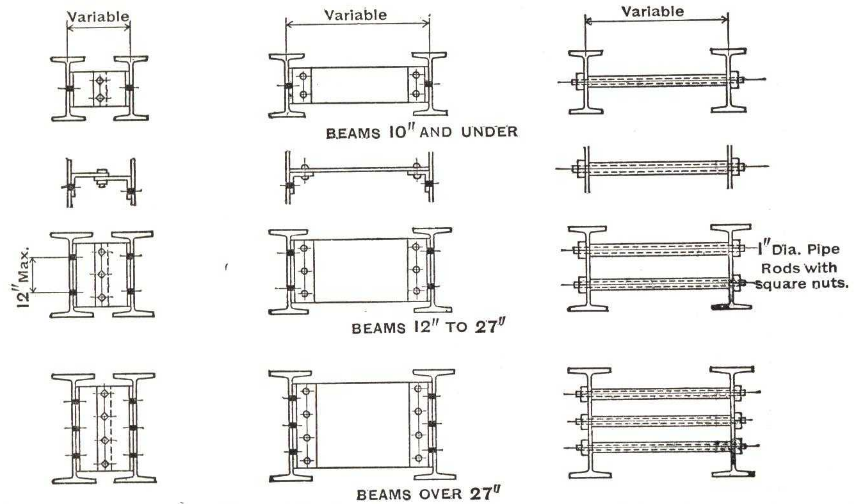
Standard Section		3½ In. Bearing		5½ In. Bearing	
Depth	Wt. Lb.	Max. React. Kips	Min. Span Feet	Max. React. Kips	Min. Span Feet
24	120	104	16.1	142	11.8
	105.9	82	19.0	112	13.9
	100	92	14.3	128	10.3
	90	77	16.1	107	11.6
	79.9	62	18.7	86	13.5
20	95	101	10.6	139	7.7
	85	82	12.2	113	8.9
	75	78	10.8	109	7.7
	65.4	61	12.8	85	9.2
18	70	83	8.2	117	5.8
	54.7	54	10.9	76	7.8
15	50	63	6.8	89	4.8
	42.9	47	8.4	67	5.9
12	50	79	4.2	107†	3.1†
	40.8	53	5.6	72†	4.1†
	35	48	5.3	67†	3.8†
	31.8	39	6.2	55†	4.4†
10	35	64	3.0	77†	2.5†
	25.4	34	4.8	40	4.1†
8	23	46	2.3		
	18.4	28	3.4		

†These spans are governed by web shear.

BEAM SEPARATORS

TYPICAL BUILT-UP SEPARATORS

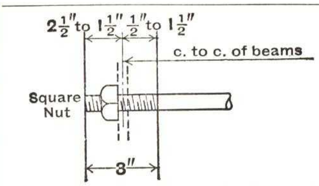
ANGLE | PLATE AND ANGLE | PIPE



Above sketches indicate representative practice. Separators should be spaced approximately 5′0″ center to center; thickness and size of material and number of bolts and rivets to be adapted to conditions.

TIE RODS AND ANCHORS

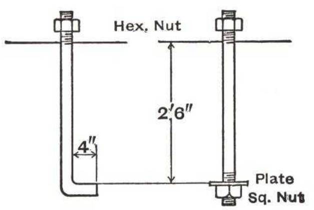
TIE RODS



Length "l" o. to o. of rod should be specified in multiples of 3 inches.

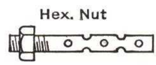
Diameter In.	Total Weight including two nuts, Lb.
⅝	$.087l + .21$
¾	$.125l + .28$
⅞	$.170l + .46$
1	$.223l + .70$

BUILT-IN ANCHOR BOLTS



In general, built-in anchor bolts should extend into the masonry not less than 2′ 6″, and farther when necessary.

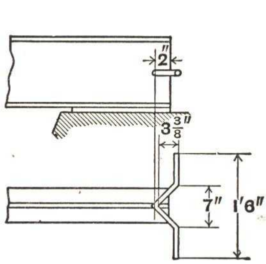
SWEDGE BOLTS



Weight includes one hexagon nut

Diam. In.	Length	Weight Lb.
1	1′ 0″	3.1
1¼	1′ 3″	6.0
1½	1′ 3″	8.7

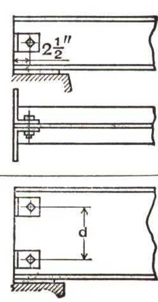
GOVERNMENT ANCHORS



¾″ Rod 1′ 9″ Long. Weight 3 pounds

ANGLE WALL ANCHORS

Depth of Beam In.	d In.	Weight with Bolts Lb.
10 and under		7
12-14	6	
15-16	9	
18	9	14
20-21	12	
24 & over	12	



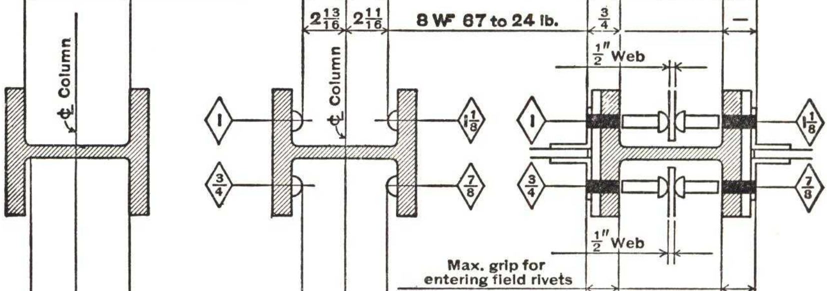
Angles 6 x 4 x ⅜ x 3″, Bolts ¾″

FIELD RIVET AND ERECTION CLEARANCES

RIVET CLEARANCE—WF COLUMNS

This dimension constant for WF column sections of same nominal depth.

$5\frac{9}{16}$	$5\frac{7}{16}$	14 WF 426 to 43 lb.	$3\frac{1}{8}$	3
$4\frac{11}{16}$	$4\frac{5}{8}$	12 WF 190 to 40 lb.	$2\frac{3}{8}$	$2\frac{1}{4}$
$3\frac{11}{16}$	$3\frac{5}{8}$	10 WF 112 to 33 lb.	$1\frac{1}{2}$	$1\frac{1}{2}$
$2\frac{13}{16}$	$2\frac{11}{16}$	8 WF 67 to 24 lb.	$\frac{3}{4}$	—

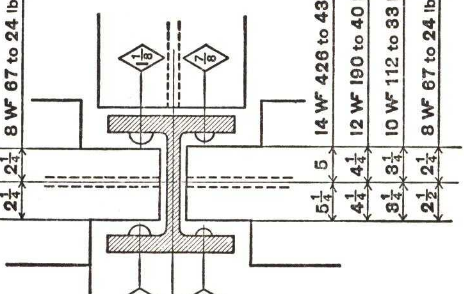


$5\frac{11}{16}$	$6\frac{5}{16}$	14 WF 426 to 43 lb.	$5\frac{3}{4}$	$5\frac{5}{8}$	14 WF 426 to 43 lb.	$3\frac{1}{2}$	$3\frac{3}{8}$
$4\frac{7}{8}$	$5\frac{7}{16}$	12 WF 190 to 40 lb.	$4\frac{7}{8}$	$4\frac{3}{4}$	12 WF 190 to 40 lb.	$2\frac{3}{4}$	$2\frac{5}{8}$
$3\frac{15}{16}$	$4\frac{7}{16}$	10 WF 112 to 33 lb.	$3\frac{7}{8}$	$3\frac{3}{4}$	10 WF 112 to 33 lb.	$1\frac{7}{8}$	$1\frac{5}{8}$
$3\frac{3}{16}$	$3\frac{9}{16}$	8 WF 67 to 24 lb.	3	$2\frac{7}{8}$	8 WF 67 to 24 lb.	$1\frac{1}{4}$	1

Based on Dimensions of Structural Rivets, page 160, and Length of Structural Rivets, page 162.

FLANGE CUTS FOR COLUMN WEB CONNECTIONS

	14 WF 426 to 43 lb.	12 WF 190 to 40 lb.	10 WF 112 to 33 lb.	8 WF 67 to 24 lb.
Left, upper	5	4	3	$2\frac{1}{4}$
Left, lower	5	$4\frac{1}{4}$	$3\frac{1}{4}$	$2\frac{1}{4}$
Right, upper	5	$4\frac{1}{4}$	$3\frac{1}{4}$	$2\frac{1}{4}$
Right, lower	$5\frac{1}{4}$	$4\frac{1}{4}$	$3\frac{1}{4}$	$2\frac{1}{2}$



When beams framing to the flanges of columns interfere with beams framing to the web of the column, the latter must be cut as shown.

In all cases where members must be erected by dropping down, allow at least $\frac{1}{2}''$ clearance at rivet heads.

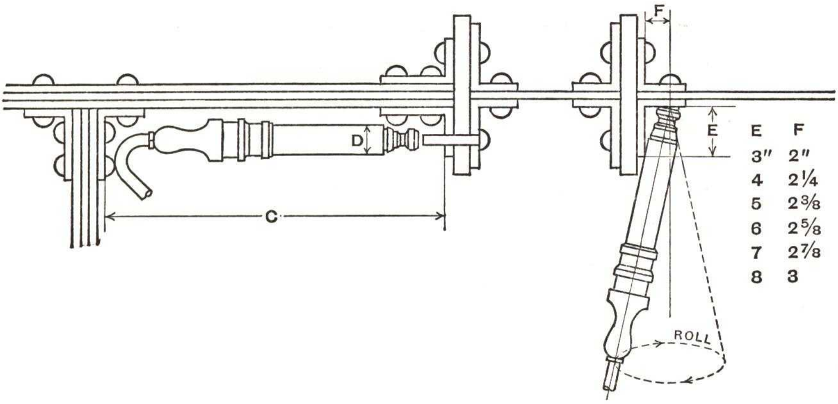
9	14 WF 426 to 142 lb.
8	14 WF 136 to 87 lb.
7	14 WF 84 to 78; 12 WF 190 to 65 lb.
6	14 WF 74 to 61; 12 WF 58 and 53; 10 WF 112 to 49 lb.
5	14 WF 53 to 43; 12 WF 50 to 40; 10 WF 45 to 33; 8 WF 67 to 31 lb.
4	8 WF 28 and 24 lb.

Based on Dimensions of Structural Rivets, page 160.

ERECTION CLEARANCES

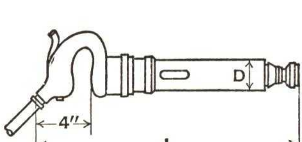
FOR INSERTING AND DRIVING RIVETS

No.	Max. Rivet	Diam. D Ins.	Str. Ins.	Wt. Lbs.	A Length L Ins.	A Clear. C Ins.	B Length L_1 Ins.	B Clear. C Ins.	All hammers except No. 130 and No. 11 can be fitted with inverted handles. These are for crowded work and are only provided by special arrangement. No. 130 is a jam riveter for close quarter work.
130	7/8	3 1/16	4	15	....	....	9	12	Used only to drive in close quarters.
50	3/4	2 5/16	5	20	....	....	14	17	
60	3/4	2 7/16	6	23	19 1/2	24	15 1/2	19	Rarely used.
80	1	2 7/16	8	25	21 1/2	26	17 1/2	21	Used for all except heaviest riveting.
90	1 1/4	2 7/16	9	26	23 3/4	28	19 3/4	23	Used for heaviest riveting.
11	1 1/2	2 7/16	11	32	26 1/2	31	....	....	

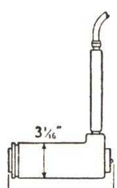


E	F
3″	2″
4	2 1/4
5	2 3/8
6	2 5/8
7	2 7/8
8	3

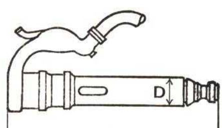
If hammer can be "rolled," easier driving and more symmetrical heads are obtained. To permit this, distance "F" must be as given here and field rivets must have a perfect stagger with shop rivets.



A—Standard Open Handle



Jam Riveter
No. 130



B—Inverted Handle

PIPE RAILING

TYPICAL DETAILS SHOWING USE OF STANDARD FITTINGS

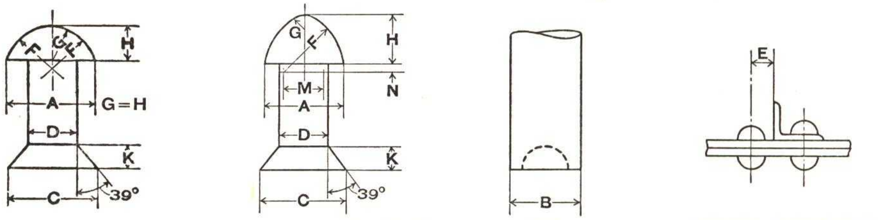
The typical details illustrating the use of standard fittings in the assembly of pipe railing, which were shown in earlier editions and earlier printings of this edition, are now deleted. In recent years considerable difficulty has been experienced in the procurement of these fittings, because of the widespread substitution of welded pipe railing for the earlier threaded type. Variations of some of the items formerly shown are still procurable from manufacturers of plumbing supplies.

PIPE RAILING

TYPICAL DETAILS SHOWING USE OF SPECIAL FITTINGS

SEE NOTE ON PAGE 158

DIMENSIONS OF STRUCTURAL RIVETS

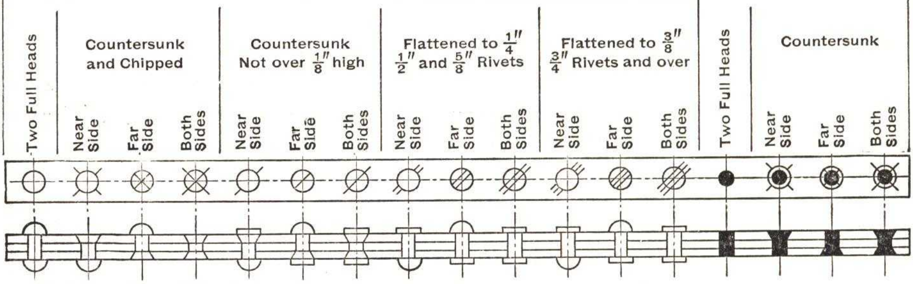


DRIVEN HEADS MANUFACTURED HEADS DIE DRIVING CLEARANCE

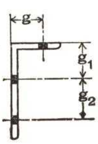
"Basic Dimensions", High Button (Acorn) Heads: American Institute of Bolt, Nut and Rivet Mfrs., 1937.

Dia. of Rivet, Inches				1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Driven Head Inches	Full	A	1.5 D + 1/8	7/8	1 1/16	1 1/4	1 7/16	1 5/8	1 13/16	2	2 3/16	2 3/8
		H	.425 A	3/8	7/16	17/32	5/8	11/16	3/4	27/32	15/16	1
		F	1.5 H	9/16	11/16	13/16	15/16	1 1/32	1 5/32	1 9/32	1 13/32	1 1/2
	Ctsk.	C	1.81 D	29/32	1 1/8	1 11/32	1 19/32	1 13/16	2 1/32	2 1/4	2 1/2	2 23/32
		K	.5 D	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4
Manufactured Head Inches	Full	A	1.5 D + 1/32	25/32	31/32	1 5/32	1 11/32	1 17/32	1 23/32	1 29/32	2 3/32	2 9/32
		H	.75 D + 1/8	1/2	19/32	11/16	25/32	7/8	31/32	1 1/16	1 5/32	1 1/4
		F	.75 D + 9/32	21/32	3/4	27/32	15/16	1 1/32	1 1/8	1 7/32	1 5/16	1 13/32
		M	.50	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
		N	.094	3/32	3/32	3/32	3/32	3/32	3/32	3/32	3/32	3/32
		G	.75 D — 9/32	3/32	3/16	9/32	3/8	15/32	9/16	21/32	3/4	27/32
	Ctsk.	C	1.81 D	29/32	1 1/8	1 11/32	1 19/32	1 13/16	2 1/32	2 1/4	2 1/2	2 23/32
		K	.5 D	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4
Die, In.		B		1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4
Driving Clearance Inches			E (min.)	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4
			E (pref.)	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2

CONVENTIONAL SIGNS FOR RIVETING



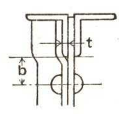
USUAL GAGES FOR ANGLES, INCHES

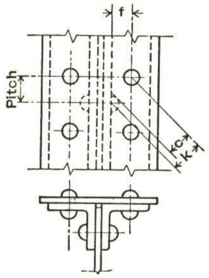


Leg	8	7	6	5	4	3 1/2	3	2 1/2	2	1 3/4	1 1/2	1 3/8	1 1/4	1
g	4 1/2	4	3 1/2	3	2 1/2	2	1 3/4	1 3/8	1 1/8	1	7/8	7/8	3/4	5/8
g_1	3	2 1/2	2 1/4	2										
g_2	3	3	2 1/2	1 3/4										

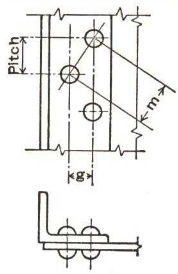
CRIMPS

b = t + 1 1/2"
Min. = 2"





RIVET SPACING



MINIMUM PITCH FOR MACHINE RIVETING

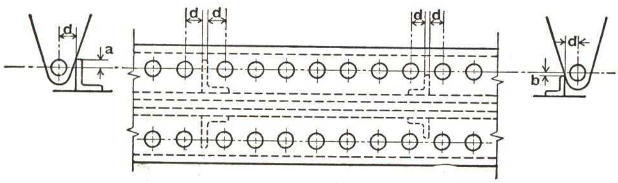
Dia. of Rivet	c	k	Distance, f, Inches 1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8	2 1/2	2 3/4	3
3/8	7/8	1 3/16	1/4	0												
1/2	1	1 3/8	3/4	1/2	0											
5/8	1 1/8	1 9/16	1 1/8	1	3/4	3/8	0									
3/4	1 1/4	1 3/4	......	1 1/4	1 1/8	1	3/4	0								
7/8	1 3/8	2	......	......	1 1/2	1 3/8	1 1/8	7/8	5/8	0						
1	1 1/2	2 3/16	......	......	......	1 5/8	1 1/2	1 3/8	1 1/8	7/8	1/2	0				
1 1/8	1 5/8	2 3/8	......	......	......	......	1 3/4	1 5/8	1 1/2	1 3/8	1 1/8	7/8	0			
1 1/4	1 3/4	2 5/8	......	......	......	......	......	2	1 7/8	1 3/4	1 1/2	1 1/4	1	5/8	0	
1 3/8	1 7/8	2 13/16	......	......	......	......	......	......	2 1/8	2	1 7/8	1 3/4	1 1/2	1 1/4	1/2	0
1 1/2	2	3	......	......	......	......	......	......	......	2 1/4	2 1/8	2	1 7/8	1 5/8	1 1/8	0

MINIMUM PITCH TO MAINTAIN 3 DIAMETERS C. TO C.

Dia. of Rivet	m	Distance, g, Inches 1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4	4	4 1/4	4 1/2
3/8	1 1/8	1/2	0													
1/2	1 1/2	1 1/8	7/8	0												
5/8	1 7/8	1 5/8	1 3/8	1 1/8	5/8	0										
3/4	2 1/4	2	1 7/8	1 5/8	1 3/8	1	0									
7/8	2 5/8	2 1/2	2 3/8	2 1/8	2	1 3/4	1 3/8	3/4	0							
1	3	2 7/8	2 3/4	2 5/8	2 1/2	2 1/4	2	1 5/8	1 1/8	0						
1 1/8	3 3/8	3 1/4	3 1/8	3	2 7/8	2 3/4	2 1/2	2 1/4	2	1 1/2	7/8	0				
1 1/4	3 3/4	3 5/8	3 1/2	3 3/8	3 3/8	3 1/4	3	2 3/4	2 1/2	2 1/4	1 7/8	1 3/8	0			
1 3/8	4 1/8	4	4	3 7/8	3 3/4	3 5/8	3 1/2	3 1/4	3 1/8	2 7/8	2 1/2	2 1/8	1 3/4	1	0	
1 1/2	4 1/2	4 3/8	4 3/8	4 1/4	4 1/8	4	3 7/8	3 3/4	3 1/2	3 3/8	3 1/8	2 7/8	2 1/2	2	1 1/2	0

COVER PLATE RIVETING

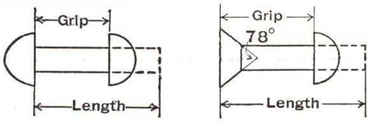
a In.	d In.
1/2	2 1/2
1	2 5/8
1 1/2	2 3/4
2	2 3/4
2 1/2	2 7/8
3	2 7/8
3 1/2	3
4	3 1/8
5	3 1/4
6	3 3/8



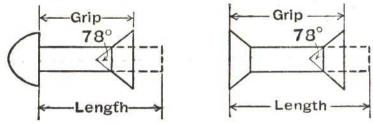
b In.	d In.
	2 1/2
1/2	2 3/8
3/4	2 1/4
1	2 1/4
1 1/4	2 1/8
1 1/2	2
1 3/4	1 3/4
2	1 1/2
2 1/4	1
2 1/2	......

LENGTH OF STRUCTURAL RIVETS

LENGTH OF UNDRIVEN RIVETS, IN INCHES, FOR VARIOUS GRIPS



FULL HEAD



COUNTERSUNK HEAD

Full Head

Grip Inches	Diameter of Rivet, Inches: 1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
1/2	1 5/8	1 7/8	1 7/8	2	2 1/8		
5/8	1 3/4	2	2	2 1/8	2 1/4		
3/4	1 7/8	2 1/8	2 1/8	2 1/4	2 3/8		
7/8	2	2 1/4	2 1/4	2 3/8	2 1/2		
1	2 1/4	2 3/8	2 3/8	2 1/2	2 5/8	2 3/4	2 7/8
1/8	2 3/8	2 1/2	2 1/2	2 5/8	2 3/4	2 7/8	3
1/4	2 1/2	2 5/8	2 5/8	2 3/4	2 7/8	3	3 1/8
3/8	2 5/8	2 3/4	2 3/4	2 7/8	3	3 1/8	3 1/4
1/2	2 7/8	3	3	3 1/8	3 1/4	3 3/8	3 1/2
5/8	3	3 1/8	3 1/8	3 1/4	3 3/8	3 1/2	3 5/8
3/4	3 1/8	3 1/4	3 1/4	3 1/2	3 5/8	3 3/4	3 7/8
7/8	3 1/4	3 3/8	3 3/8	3 5/8	3 3/4	3 7/8	4
2	3 1/2	3 1/2	3 5/8	3 3/4	3 7/8	4	4 1/8
1/8	3 5/8	3 5/8	3 3/4	3 7/8	4	4 1/8	4 1/4
1/4	3 3/4	3 7/8	3 7/8	4	4 1/8	4 1/4	4 3/8
3/8	4	4	4	4 1/8	4 1/4	4 3/8	4 1/2
1/2	4 1/8	4 1/8	4 1/8	4 1/4	4 3/8	4 1/2	4 5/8
5/8	4 1/4	4 1/4	4 1/4	4 3/8	4 1/2	4 5/8	4 3/4
3/4	4 3/8	4 3/8	4 3/8	4 1/2	4 5/8	4 3/4	4 7/8
7/8	4 5/8	4 5/8	4 5/8	4 5/8	4 3/4	4 7/8	5
3	....	4 3/4	4 3/4	4 7/8	5	5 1/8	5 1/4
1/8	....	4 7/8	4 7/8	5	5 1/8	5 1/4	5 3/8
1/4	....	5	5	5 1/8	5 1/4	5 3/8	5 1/2
3/8	....	5 1/8	5 1/8	5 1/4	5 3/8	5 1/2	5 5/8
1/2	....	5 3/8	5 3/8	5 3/8	5 1/2	5 5/8	5 3/4
5/8	....	5 1/2	5 1/2	5 1/2	5 5/8	5 3/4	5 7/8
3/4	....	5 5/8	5 5/8	5 5/8	5 3/4	5 7/8	6
7/8	....	5 3/4	5 3/4	5 3/4	5 7/8	6	6 1/8
4	....	....	5 7/8	6	6	6 1/8	6 1/4
1/8	....	....	6	6 1/8	6 1/4	6 3/8	6 1/2
1/4	....	....	6 1/8	6 1/4	6 3/8	6 1/2	6 5/8
3/8	....	....	6 3/8	6 1/2	6 1/2	6 5/8	6 3/4
1/2	....	....	6 1/2	6 5/8	6 5/8	6 3/4	6 7/8
5/8	....	....	6 5/8	6 3/4	6 3/4	6 7/8	7
3/4	....	....	6 3/4	6 7/8	6 7/8	7	7 1/8
7/8	....	....	6 7/8	7	7	7 1/8	7 1/4
5	....	....	....	7 1/8	7 1/8	7 1/4	7 3/8
1/8	....	....	....	7 1/4	7 1/4	7 3/8	7 1/2
1/4	....	....	....	7 3/8	7 3/8	7 1/2	7 5/8
3/8	....	....	....	7 5/8	7 5/8	7 3/4	7 3/4
1/2	....	....	....	7 3/4	7 3/4	7 7/8	7 7/8
5/8	....	....	....	7 7/8	7 7/8	8	8
3/4	....	....	....	8	8	8 1/8	8 1/8
7/8	....	....	....	8 1/8	8 1/8	8 1/4	8 1/4

Countersunk Head

Grip Inches	Diameter of Rivet, Inches: 1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
1/2	1	1	1 1/8	1 1/4	1 1/4		
5/8	1 1/8	1 1/4	1 1/4	1 3/8	1 3/8		
3/4	1 3/8	1 3/8	1 3/8	1 1/2	1 1/2		
7/8	1 1/2	1 1/2	1 1/2	1 5/8	1 5/8		
1	1 5/8	1 5/8	1 5/8	1 3/4	1 3/4	1 7/8	1 7/8
1/8	1 3/4	1 3/4	1 7/8	1 7/8	1 7/8	2	2
1/4	2	2	2	2	2	2 1/8	2 1/8
3/8	2 1/8	2 1/8	2 1/8	2 1/4	2 1/4	2 3/8	2 3/8
1/2	2 1/4	2 1/4	2 1/4	2 3/8	2 3/8	2 1/2	2 1/2
5/8	2 3/8	2 3/8	2 3/8	2 1/2	2 1/2	2 5/8	2 5/8
3/4	2 5/8	2 5/8	2 5/8	2 5/8	2 5/8	2 3/4	2 3/4
7/8	2 3/4	2 3/4	2 3/4	2 3/4	2 3/4	2 7/8	2 7/8
2	2 7/8	2 7/8	2 7/8	2 7/8	2 7/8	3	3
1/8	3 1/8	3	3	3	3	3 1/8	3 1/8
1/4	3 1/4	3 1/8	3 1/8	3 1/8	3 1/4	3 1/4	3 1/4
3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8	3 3/8
1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 5/8	3 5/8
5/8	3 3/4	3 5/8	3 5/8	3 5/8	3 5/8	3 3/4	3 3/4
3/4	3 7/8	3 3/4	3 3/4	3 3/4	3 3/4	3 7/8	3 7/8
7/8	4	3 7/8	3 7/8	3 7/8	3 7/8	4	4
3	....	4 1/8	4 1/8	4 1/8	4 1/8	4 1/8	4 1/8
1/8	....	4 1/4	4 1/4	4 1/4	4 1/4	4 1/4	4 1/4
1/4	....	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8
3/8	....	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2
1/2	....	4 5/8	4 5/8	4 5/8	4 5/8	4 5/8	4 5/8
5/8	....	4 3/4	4 3/4	4 3/4	4 3/4	4 7/8	4 7/8
3/4	....	5	5	5	5	5	5
7/8	....	5 1/8	5 1/8	5 1/8	5 1/8	5 1/8	5 1/8
4	....	....	5 1/4	5 1/4	5 1/4	5 1/4	5 1/4
1/8	....	....	5 3/8	5 3/8	5 3/8	5 3/8	5 3/8
1/4	....	....	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2
3/8	....	....	5 5/8	5 5/8	5 5/8	5 5/8	5 5/8
1/2	....	....	5 3/4	5 3/4	5 3/4	5 3/4	5 3/4
5/8	....	....	6	6	6	6	6
3/4	....	....	6 1/8	6 1/8	6 1/8	6 1/8	6 1/8
7/8	....	....	6 1/4	6 1/4	6 1/4	6 1/4	6 1/4
5	....	....	....	6 3/8	6 3/8	6 3/8	6 3/8
1/8	....	....	....	6 1/2	6 1/2	6 1/2	6 1/2
1/4	....	....	....	6 5/8	6 5/8	6 5/8	6 5/8
3/8	....	....	....	6 3/4	6 3/4	6 3/4	6 3/4
1/2	....	....	....	6 7/8	6 7/8	6 7/8	6 7/8
5/8	....	....	....	7	7	7	7
3/4	....	....	....	7 1/4	7 1/4	7 1/4	7 1/4
7/8	....	....	....	7 3/8	7 3/8	7 3/8	7 3/8

Above table may vary from standard practice of individual fabricators and should be checked against such standards by user.

WEIGHT OF STRUCTURAL RIVETS

WEIGHT WITH ONE HIGH BUTTON (ACORN) MANUFACTURED HEAD IN POUNDS PER 100

Length Inches	Diameter of Rivet, Inches							Length Inches	Diameter of Rivet, Inches						
	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4		1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
								5	......	50	74	104	138	180	226
								1/8	......	51	76	106	141	183	230
1 1/4	11							1/4	......	52	78	108	144	187	234
3/8	12							3/8	......	53	79	110	147	190	239
1/2	12	20	31	45	60	81	104	1/2	......	54	81	113	149	194	243
5/8	13	21	32	47	63	85	108	5/8	......	55	82	115	152	197	247
3/4	14	22	33	49	66	88	113	3/4	......	57	84	117	155	201	252
7/8	14	23	35	51	69	92	117	7/8	......	58	85	119	158	204	256
2	15	24	37	53	72	95	122	6	......	......	87	121	161	208	261
1/8	16	25	39	55	74	99	126	1/8	......	......	89	123	163	212	265
1/4	17	26	40	57	77	102	130	1/4	......	......	90	125	166	215	269
3/8	17	27	42	59	80	106	135	3/8	......	......	92	127	169	219	274
1/2	18	28	43	62	83	109	139	1/2	......	......	93	130	172	222	278
5/8	19	29	45	64	85	113	143	5/8	......	......	95	132	174	226	282
3/4	19	31	46	66	88	116	148	3/4	......	......	96	134	177	229	287
7/8	20	32	48	68	91	120	152	7/8	......	......	98	136	180	233	291
3	21	33	50	70	94	123	156	7	......	......	100	138	183	236	295
1/8	21	34	51	72	97	127	161	1/8	......	......	101	140	186	240	300
1/4	22	35	53	74	99	131	165	1/4	......	......	103	142	188	243	304
3/8	23	36	54	76	102	134	169	3/8	......	......	104	144	191	247	308
1/2	23	37	56	79	105	138	174	1/2	......	......	106	147	194	250	313
5/8	24	38	57	81	108	141	178	5/8	......	......	107	149	197	254	317
3/4	25	39	59	83	110	145	182	3/4	......	......	109	151	199	257	321
7/8	26	40	60	85	113	148	187	7/8	......	......	110	153	202	261	326
4	26	41	62	87	116	152	191	8	......	......	......	155	205	264	330
1/8	27	42	64	89	119	155	195	1/8	......	......	......	157	208	268	334
1/4	28	44	65	91	122	159	200	1/4	......	......	......	159	211	271	339
3/8	28	45	67	93	124	162	204	3/8	......	......	......	161	213	275	343
1/2	29	46	68	96	127	166	208	1/2	......	......	......	164	216	278	347
5/8	30	47	70	98	130	169	213	5/8	......	......	......	166	219	282	352
3/4	30	48	71	100	133	173	217	3/4	......	......	......	168	222	285	356
7/8	31	49	73	102	135	176	221	7/8	......	......	......	170	224	289	360

WEIGHT WITH ONE COUNTERSUNK HEAD IN POUNDS PER 100

For Countersunk Rivets, use weight given above with following deductions.	Diameter of Rivet, Inches						
	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Deduction, Lb.	3	4	7	12	18	26	36

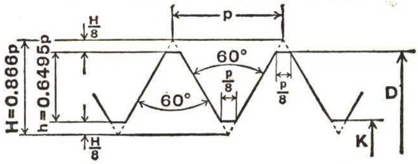
WEIGHT OF HIGH BUTTON (ACORN) HEADS AFTER DRIVING

Diameter of Rivet, Inches	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Weight per 100 Heads, Lb.	4	7	12	18	26	36	48

SCREW THREADS

American National Form

American Standard, B 1.1—1935.



DIAMETER		AREA		Number of Threads per Inch	DIAMETER		AREA		Number of Threads per Inch
Total D In.	Net K In.	Total Dia., D Sq. In.	Net Dia., K Sq. In.		Total D In.	Net K In.	Total Dia., D Sq. In.	Net Dia., K Sq. In.	
1/4	.185	.049	.027	20	3	2.675	7.069	5.621	4
3/8	.294	.110	.068	16	3 1/4	2.925	8.296	6.720	4
1/2	.400	.196	.126	13	3 1/2	3.175	9.621	7.918	4
5/8	.507	.307	.202	11	3 3/4	3.425	11.045	9.214	4
3/4	.620	.442	.302	10	4	3.675	12.566	10.608	4
7/8	.731	.601	.419	9					
					4 1/4	3.798	14.186	11.330	2 7/8
1	.838	.785	.551	8	4 1/2	4.028	15.904	12.741	2 3/4
1 1/8	.939	.994	.693	7	4 3/4	4.255	17.721	14.221	2 5/8
1 1/4	1.064	1.227	.890	7					
1 3/8	1.158	1.485	1.054	6					
1 1/2	1.283	1.767	1.294	6	5	4.480	19.635	15.766	2 1/2
1 3/4	1.490	2.405	1.744	5	5 1/4	4.730	21.648	17.574	2 1/2
					5 1/2	4.953	23.758	19.268	2 3/8
2	1.711	3.142	2.300	4 1/2	5 3/4	5.203	25.967	21.262	2 3/8
2 1/4	1.961	3.976	3.021	4 1/2					
2 1/2	2.175	4.909	3.716	4	6	5.423	28.274	23.095	2 1/4
2 3/4	2.425	5.940	4.619	4					

Sizes over 4″ are old U. S. Standard; there is no American Standard.
Dimensions are maximum; specify "Free Fit—Class 2." For Bolts from 2½″ to 6″ diameter it is always necessary to bill the number of threads per inch.

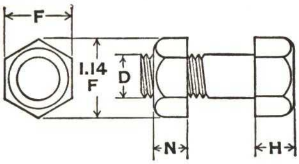
LENGTH OF BOLT THREADS

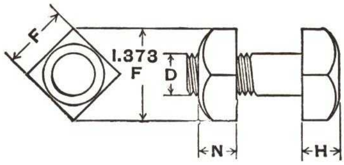
American Standard, B 18.2—1941.

Length of Bolt Inches	Diameter of Bolt, Inches														
	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8, 1 1/4	1 3/8, 1 1/2	1 5/8, 1 3/4	1 7/8, 2	2 1/4	2 1/2	2 3/4	3
	Minimum Thread Length														
1	3/4	3/4	3/4	3/4											
1 1/4	3/4	3/4	1	1	1										
1 1/2	3/4	7/8	1	1 1/8	1 1/8	1 1/8									
1 3/4	3/4	7/8	1	1 3/16	1 3/8	1 3/8	1 3/8								
2	3/4	1	1 1/4	1 1/4	1 3/8	1 9/16	1 5/8	1 5/8							
2 1/2	3/4	1	1 1/4	1 1/2	1 1/2	1 9/16	1 3/4	2	2						
3	7/8	1	1 1/4	1 1/2	1 3/4	1 3/4	1 3/4	2 1/8	2 1/2	2 1/2					
4	7/8	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/4	2 1/2	2 7/8	3 1/4	3 1/4	3 1/4		
5	7/8	1 3/16	1 1/4	1 1/2	1 3/4	2	2 1/4	2 3/4	2 3/4	2 7/8	3 1/4	3 5/8	4	4 1/8	4 1/4
6	7/8	1 3/16	1 1/2	1 1/2	1 3/4	2	2 1/4	2 3/4	3 1/4	3 1/4	3 1/4	3 5/8	4	4 1/8	4 3/4
8	7/8	1 3/16	1 1/2	1 13/16	2	2	2 1/4	2 3/4	3 1/4	3 3/4	4	4	4	4 1/8	4 3/4
10	7/8	1 3/16	1 1/2	1 13/16	2 1/8	2 7/16	2 1/2	2 3/4	3 1/4	3 3/4	4 1/4	4 3/4	4 3/4	4 3/4	4 3/4
12	7/8	1 3/16	1 1/2	1 13/16	2 1/8	2 7/16	2 3/4	2 3/4	3 1/4	3 3/4	4 1/4	4 3/4	5 1/4	5 3/4	6 1/4
16	1	1 3/16	1 1/2	1 13/16	2 1/8	2 7/16	2 3/4	3 1/4	3 1/4	3 3/4	4 1/4	4 3/4	5 1/4	5 3/4	6 1/4
20	1	1 3/8	1 1/2	1 13/16	2 1/8	2 7/16	2 3/4	3 3/8	4	4 5/8	4 3/4	4 3/4	5 1/4	5 3/4	6 1/4
30			1 3/4	1 13/16	2 1/8	2 7/16	2 3/4	3 3/8	4	4 5/8	5 1/4	5 7/8	6 1/2	6 1/2	6 1/2

For intermediate bolt lengths, same minimum thread length as for next shorter tabulated length.

BOLT HEADS AND NUTS





HEADS AND NUTS		American Standard Regular	American Standard Heavy
HEAD	Height, H	2/3 D	3/4 D + 1/16″
	Short Dia., F	1 1/2 D	1 1/2 D + 1/8″
NUT	Height, N	7/8 D	D
	Short Dia., F	1 1/2 D + 1/16″ (D = 5/8″ or less) 1 1/2 D (D greater than 5/8″)	1 1/2 D + 1/8″

American Standard Bolt and Nut dimensions rounded to the nearest 1/16 inch, are those adopted by American Institute of Bolt, Nut and Rivet Manufacturers, American Standard B 18.2—1941. "American Standard Regular" formerly called Manufacturers Standard, American Standard, etc. "American Standard Heavy" formerly called United States Standard. Some fabricators have standard heads and nuts differing only slightly from the table. For bolts with countersunk heads the included angle is 78 degrees, the same as for rivets. See page 160 for dimensions.

STANDARD DIMENSIONS

Dia. of Bolt In.	Series	HEAD Hexagon Diameter, In. Long	HEAD Hexagon Diameter, In. Short	HEAD Height In.	HEAD Square Diameter, In. Long	HEAD Square Diameter, In. Short
1/4	American Standard Regular	7/16	3/8	3/16	1/2	3/8
3/8		5/8	9/16	1/4	3/4	9/16
1/2		7/8	3/4	5/16	1	3/4
5/8		1 1/16	15/16	7/16	1 5/16	15/16
3/4		1 5/16	1 1/8	1/2	1 9/16	1 1/8
7/8		1 1/2	1 5/16	9/16	1 13/16	1 5/16
1		1 11/16	1 1/2	5/8	2 1/16	1 1/2
1 1/8		1 15/16	1 11/16	3/4	2 5/16	1 11/16
1 1/4		2 1/8	1 7/8	13/16	2 9/16	1 7/8
1 3/8		2 3/8	2 1/16	15/16	2 13/16	2 1/16
1 1/2		2 9/16	2 1/4	1	3 1/16	2 1/4
1 5/8		2 3/4	2 7/16	1 1/16	3 3/8	2 7/16
1 3/4		3	2 5/8	1 3/16	3 5/8	2 5/8
1 7/8		3 3/16	2 13/16	1 1/4	3 7/8	2 13/16
2		3 7/16	3	1 5/16	4 1/8	3
2 1/4		3 7/8	3 3/8	1 1/2	4 5/8	3 3/8
2 1/2		4 1/4	3 3/4	1 11/16	5 1/8	3 3/4
2 3/4		4 11/16	4 1/8	1 13/16	5 11/16	4 1/8
3		5 1/8	4 1/2	2	6 3/16	4 1/2
3 1/4	Former Manufacturers Std.	5 9/16	4 7/8	2 3/16	6 11/16	4 7/8
3 1/2		6	5 1/4	2 5/16	7 3/16	5 1/4
3 3/4		6 7/16	5 5/8	2 1/2	7 3/4	5 5/8
4		6 7/8	6	2 11/16	8 1/4	6
4 1/4		7 1/4	6 3/8	2 13/16	8 3/4	6 3/8
4 1/2		7 11/16	6 3/4	3	9 1/4	6 3/4
4 3/4		8 1/8	7 1/8	3 3/16	9 13/16	7 1/8
5		8 9/16	7 1/2	3 5/16	10 5/16	7 1/2
5 1/4		9	7 7/8	3 1/2	10 13/16	7 7/8
5 1/2		9 3/8	8 1/4	3 11/16	11 5/16	8 1/4
5 3/4		9 13/16	8 5/8	3 13/16	11 13/16	8 5/8
6		10 1/4	9	4	12 3/8	9

Dia. of Bolt In.	Series	NUT Hexagon Diameter, In. Long	NUT Hexagon Diameter, In. Short	NUT Height In.	NUT Square Diameter, In. Long	NUT Square Diameter, In. Short
1/4	American Standard Regular	1/2	7/16	1/4	5/8	7/16
3/8		11/16	5/8	5/16	7/8	5/8
1/2		15/16	13/16	7/16	1 1/8	13/16
5/8		1 1/8	1	9/16	1 3/8	1
3/4		1 5/16	1 1/8	11/16	1 9/16	1 1/8
7/8		1 1/2	1 5/16	3/4	1 13/16	1 5/16
1		1 11/16	1 1/2	7/8	2 1/16	1 1/2
1 1/8		1 15/16	1 11/16	1	2 5/16	1 11/16
1 1/4		2 1/8	1 7/8	1 1/8	2 9/16	1 7/8
1 3/8		2 3/8	2 1/16	1 1/4	2 13/16	2 1/16
1 1/2		2 9/16	2 1/4	1 5/16	3 1/8	2 1/4
1 3/8	American Standard Heavy	2 1/2	2 3/16	1 3/8	3	2 3/16
1 1/2		2 11/16	2 3/8	1 1/2	3 1/4	2 3/8
1 5/8		2 15/16	2 9/16	1 5/8	3 1/2	2 9/16
1 3/4		3 1/8	2 3/4	1 3/4	3 3/4	2 3/4
1 7/8		3 3/8	2 15/16	1 7/8	4 1/16	2 15/16
2		3 9/16	3 1/8	2	4 5/16	3 1/8
2 1/4		4	3 1/2	2 1/4	4 13/16	3 1/2
2 1/2		4 7/16	3 7/8	2 1/2	5 5/16	3 7/8
2 3/4		4 7/8	4 1/4	2 3/4	5 13/16	4 1/4
3		5 1/4	4 5/8	3	6 3/8	4 5/8
3 1/4		5 11/16	5	3 1/4	6 7/8	5
3 1/2		6 1/8	5 3/8	3 1/2	7 3/8	5 3/8
3 3/4		6 9/16	5 3/4	3 3/4	7 7/8	5 3/4
4		7	6 1/8	4	8 7/16	6 1/8
4 1/4	Former U. S. Std.	7 7/16	6 1/2	4 1/4	8 15/16	6 1/2
4 1/2		7 13/16	6 7/8	4 1/2	9 7/16	6 7/8
4 3/4		8 1/4	7 1/4	4 3/4	9 15/16	7 1/4
5		8 11/16	7 5/8	5	10 1/2	7 5/8
5 1/4		9 1/8	8	5 1/4	11	8
5 1/2		9 9/16	8 3/8	5 1/2	11 1/2	8 3/8
5 3/4		10	8 3/4	5 3/4	12	8 3/4
6		10 3/8	9 1/8	6	12 1/2	9 1/8

WEIGHT OF BOLTS

WITH SQUARE HEADS AND HEXAGON NUTS
IN POUNDS PER 100

This head and nut combination, using "American Standard Regular" dimensions, is usual practice with many fabricators.

Length under head Inches	Diameter of Bolt in Inches										
	¼	5/16	⅜	7/16	½	⅝	¾	⅞	1	1⅛	1¼
1	2.7	5.0	7.2	11.2	14.9	28	43				
1¼	3.1	5.5	8.0	12.2	16.3	30	46	68			
1½	3.4	6.1	8.8	13.3	17.7	32	49	73	103	144	190
1¾	3.8	6.6	9.6	14.4	19.0	35	52	77	109	151	199
2	4.1	7.2	10.4	15.4	20.4	37	55	81	115	158	208
2¼	4.5	7.7	11.1	16.5	21.8	39	58	85	120	165	216
2½	4.8	8.2	11.9	17.5	23.2	41	61	90	126	172	225
2¾	5.2	8.8	12.7	18.6	24.6	43	64	94	131	179	234
3	5.5	9.3	13.5	19.7	26.0	45	68	98	137	187	242
3¼	5.9	9.9	14.3	20.7	27.4	48	71	102	142	194	251
3½	6.2	10.4	15.1	21.8	28.8	50	74	107	148	201	260
3¾	6.6	11.0	15.8	22.9	30.2	52	77	111	153	208	268
4	6.9	11.5	16.6	23.9	31.6	54	80	115	159	215	277
4¼	7.3	12.0	17.4	25.0	33.0	56	83	119	165	222	286
4½	7.6	12.6	18.2	26.1	34.4	58	86	124	170	229	294
4¾	8.0	13.1	19.0	27.1	35.7	61	89	128	176	236	303
5	8.3	13.7	19.8	28.2	37.1	63	93	132	181	243	312
5¼	8.6	14.2	20.5	29.3	38.5	65	96	136	187	250	321
5½	9.0	14.8	21.3	30.3	39.9	67	99	141	192	257	329
5¾	9.3	15.3	22.1	31.4	41.3	69	102	145	198	264	338
6	9.7	15.9	22.9	32.4	42.7	71	105	149	204	271	347
6¼	10.0	16.4	23.7	33.5	44.1	74	108	153	209	278	355
6½	10.4	16.9	24.5	34.6	45.5	76	111	158	215	285	364
6¾	10.7	17.5	25.2	35.6	46.9	78	114	162	220	292	373
7	11.1	18.0	26.0	36.7	48.3	80	118	166	226	299	381
7¼	11.4	18.6	26.8	37.8	49.7	82	121	170	231	306	390
7½	11.8	19.1	27.6	38.8	51.1	84	124	175	237	313	399
7¾	12.1	19.7	28.4	39.9	52.4	87	127	179	242	320	407
8	12.5	20.2	29.2	41.0	53.8	89	130	183	248	327	416
8½	......	21.3	30.7	43.1	56.6	93	136	192	259	341	434
9	......	22.4	32.3	45.2	59.4	98	143	200	270	356	451
9½	......	23.5	33.9	47.4	62.2	102	149	209	281	370	468
10	......	24.6	35.4	49.5	65.0	106	155	217	293	384	486
10½	......	......	37.0	51.6	67.8	111	161	226	304	398	503
11	......	......	38.6	53.7	70.5	115	168	234	315	412	520
11½	......	......	40.1	55.9	73.3	119	174	243	326	426	538
12	......	......	41.7	58.0	76.1	124	180	251	337	440	555
12½	......	......	......	60.1	78.9	128	186	260	348	454	573
13	......	......	......	62.3	81.7	132	193	268	359	468	590
13½	......	......	......	64.4	84.5	137	199	277	370	482	607
14	......	......	......	66.5	87.2	141	205	285	382	496	625
14½	......	......	......	......	90.0	145	211	294	393	510	642
15	......	......	......	......	92.8	150	218	302	404	525	660
15½	......	......	......	......	95.6	154	224	311	415	539	677
16	......	......	......	......	98.4	158	230	320	426	553	694
Per Inch additional	1.4	2.2	3.1	4.3	5.6	8.7	12.5	17.0	22.3	28.2	34.8

WEIGHT OF BOLTS

SPECIAL CASES

IN POUNDS PER 100

VARIATIONS IN HEADS OR NUTS

As stated on page 166, usual practice is Square Head and Hexagon Nut, "American Standard Regular". For other combinations of head and nut, or for "American Standard Heavy", make the appropriate deductions and additions of weights of heads and nuts as tabulated below, from the weights per 100 found on page 166.

Weight of 100 each		Diameter of Bolt, Inches										
		1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Regular	Square Heads	.7	1.4	2.2	3.2	5.1	10	18	29	42	60	84
	Hexagon Heads	.6	1.2	1.9	2.8	4.5	9	15	25	36	52	73
	Square Nuts	.81	1.7	2.3	4.1	5.6	10	14	23	35	49	67
	Hexagon Nuts	.64	1.4	1.9	3.7	4.2	9	12	18	28	42	54
Heavy	Square Heads	....	....	....	....	9.5	17	28	42	61	84	112
	Hexagon Heads	....	....	....	....	8.2	14	24	36	53	73	94
	Square Nuts	....	....	....	....	7.9	14	23	35	50	66	92
	Hexagon Nuts	....	....	....	....	6.6	11	19	28	41	56	73

HEAVY BOLTS

Weights of bolts over 1 1/4 inches in diameter may be calculated from the following data. Standard practice is "American Standard Regular" head with "American Standard Regular" or "Heavy" nut, as specified.

Weight of 100 each		Diameter of Bolt, Inches										
		1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4	4
Regular	Square Heads	143	226	343	484	660	881	1148	1452	1830	2241	2710
	Hexagon Heads	124	196	297	419	577	764	994	1257	1585	1941	2350
	Square Nuts	116	184	276	391	539	666	874				
	Hexagon Nuts	102	162	231	337	472	606	825				
Heavy	Square Heads	190	295	432	608	825	1087	1401	1775	2115	2715	3312
	Hexagon Heads	162	254	377	538	727	890	1214	1526	1906	2344	2845
	Square Nuts	154	242	355	496	674	831	1082	1767	2043	2303	2969
	Hexagon Nuts	123	208	303	422	573	742	1008	1196	1485	1789	2184
Pounds per linear inch of Shank		.5007	.6815	.8900	1.127	1.391	1.683	2.003	2.348	2.723	3.126	3.556

MINIMUM RADIUS

FOR COLD FLANGING

The following Table gives safe minimum inside radius for structural steel, A.S.T.M. Specification A7, when cold flanged with the bend transverse to the direction of final rolling. Limiting thickness, one inch.

For cold flanging thicker plates, or plates of harder steel, or for flanging with the bend parallel to the direction of final rolling, greater radii will be required, and can best be determined by experiment on representative samples.

Length of Piece	Minimum Inside Radius of Bend
Not over 18 in.	T
Over 18 and not over 120 in.	$1\frac{3}{4}$ T
Over 120 in.	$2\frac{1}{2}$ T

in which T is the thickness of the material.

PART III

ALLOWABLE LOADS

BY

A. I. S. C. SPECIFICATION

CAPACITIES OF

WIDE FLANGE, AMERICAN STANDARD AND MISCELLANEOUS SHAPES USED AS BEAMS

WIDE FLANGE, AMERICAN STANDARD AND MISCELLANEOUS SHAPES USED AS COLUMNS

COMPOUND SECTIONS USED AS COLUMNS

PIPE COLUMNS

COLUMN BASE PLATES

BEAM CONNECTIONS

PINS, RIVETS AND BOLTS

ALLOWABLE LOADS ON BEAMS

The tables of allowable loads for Wide Flange, American Standard, and Miscellaneous Shapes used as simple beams, give the total allowable uniformly distributed loads in kips, for ordinary spans laterally supported, based on the stresses specified in the A. I. S. C. Standard Specification. The loads include the weight of the beam, which should be deducted to arrive at the net load which the beam will support.

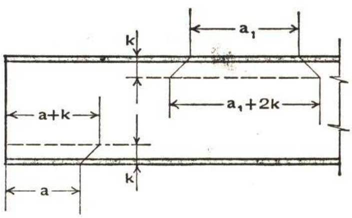
The tables are also applicable to simple beams laterally supported, carrying a single concentrated load at the center of the span. For this condition the allowable concentrated load is one-half the allowable uniformly distributed load for the same span.

It is assumed in all cases that the loads are applied normal to the X-X axis as shown in the tables of properties of shapes, and that the beam deflects vertically in the plane of bending only. If the conditions of loading involve forces outside of this plane, the allowable loads must be determined from the general theory of flexure, in accordance with the character of the load and its mode of application.

SHEARING STRESSES. With relatively short spans the allowable loads for beams and channels may be limited by the shearing or buckling strength of the web, instead of by the maximum bending stress allowed in the flanges. This limit is indicated in the tables by solid cross lines. Loads shown above these lines will produce the maximum allowable shear on the beam web.

CRIPPLING VALUES OF BEAM WEBS. Beams should be designed so the compression stress in the web at the toe of the fillet, resulting from reactions or concentrated loads, shall not exceed 24 kips per square inch figured as follows, for webs without stiffeners:

Maximum end reaction $= 24t\,(a+k)$
Maximum interior load $= 24t\,(a_1+2k)$
where t = thickness of web in inches.
k = distance from outer face of flange to web toe of fillet in inches.
a = length of bearing in inches.
a_1 = length of concentrated load in inches.



When the above values are exceeded the webs of the beams should be reinforced, or the length of bearing increased. Lack of proper lateral support for the top flanges of beams at the reaction point so decreases the crippling strength of the webs as to render such practice inadmissible.

LATERAL DEFLECTION OF BEAMS. The allowable loads given in the tables are calculated on the assumption that the compression flanges of the beams are properly secured against yielding.

These loads are however also allowable on the same spans, without side support, provided that the quantity ld/bt does not exceed 600. (See A.I.S.C. Specification Sect. 15 (a) for definition of terms.) Therefore the function d/bt, which is a beam property, is tabulated under each beam weight, and immediately below is tabulated, as L_u, the greatest span in feet for which ld/bt does not exceed 600.

When ld/bt exceeds 600, the permissible unit stress must be reduced below 20,000 p.s.i., in accordance with the formula

$$f = \frac{12{,}000{,}000}{\frac{ld}{bt}}$$

This formula may be solved by the aid of the tabulated values of d/bt. The allowable load must then be reduced below that tabulated for the span, in the same ratio as the value of f thus calculated bears to 20,000.

However, the selection of a beam for trial calculation may not be simple. It will usually be simplified by the use of the charts which appear on pages 203 to 206 hereafter.

VERTICAL DEFLECTION. In the column at the right of each page of allowable loads are given the deflections for beams of various spans carrying the tabulated allowable loads. These deflections are based on the nominal depth of beam. The following formula may be used for calculating the maximum deflection of any symmetrical beam or girder uniformly loaded:

$$\Delta = \frac{5Wl^3}{384\ E\ I}$$

where Δ = deflection in inches, W = total uniform load including weight of beam in pounds, and l = span in inches. For E = 29,000,000 pounds per square inch and flexural stress 20000 pounds per square inch the formula reduces to.

$$\Delta = \frac{0.02069\ L^2}{d}$$

where L = span in feet, and d = depth of beam or girder in inches.

The live load deflection of floor beams carrying plastered ceilings should be limited to not more than 1/360 of the span length. This limit is not reached on the span lengths herein tabulated.

STANDARD BEAM CONNECTIONS. Maximum loads are indicated in the tables on pages 175 to 199 by long horizontal dash lines for Standard "A" Series Beam Connections and by short horizontal dash lines for Standard "B" Series Connections Load shown above these lines cause the capacities of these connections to be exceeded and "H", "HH", "K" or "KK" Series or Special connections must be used.

SUMMARY

OF

NOTES ON BEAM TABLES

SYMBOLS

$$\frac{d}{bt} = \frac{\text{depth of beam}}{\text{breadth} \times \text{thickness of flange}}$$, all in inches.

Lu = length of span, in ft., up to which the tabulated loads are safe with or without lateral support.

S = Section modulus, in inches^3.

V = Maximum web shear, in kips = 13 dt

R = Maximum end reaction, in kips, for 3½ inch bearing = G (3½+k)

G = Increase in R, in kips, for each additional inch of bearing = 24 t

N = Length of bearing, in inches, to develop V = (V÷G)—k

HORIZONTAL LINES

——————— Load next above is maximum allowable shear on web.

— — — Load next below is maximum for Standard "A" Series beam connection.

– – – – – Load next below is maximum for Standard "B" Series beam connection.

(For greater loads use "H", "HH", "K" or "KK" Series, or special connections.)

BEAMS

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WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot										Deflection Inches
	36 x 16½					36 x 12					
	300	280	260	245	230	194	182	170	160	150	
d/bt	1.31	1.40	1.52	1.62	1.73	2.39	2.55	2.73	2.94	3.19	
L_u	38	35.5	32.5	30.5	28.5	20.5	19.5	18	17.0	15.5	
11									612	582	.07
12						730	684	640	601	559	.08
13						681	637	594	555	516	.10
14						632	592	552	515	479	.11
15			796	752	714	590	552	515	481	447	.13
16	902	840	793	744	696	553	518	483	451	419	.15
17	867	809	746	700	655	521	487	454	424	394	.17
18	819	764	705	661	619	492	460	429	401	373	.19
19	776	724	668	627	586	466	436	406	380	353	.21
20	737	688	634	595	557	442	414	386	361	335	.23
21	702	655	604	566	531	421	394	368	344	319	.25
22	670	625	577	540	506	402	377	351	328	305	.28
23	641	598	551	517	484	385	360	336	314	292	.30
24	614	573	528	496	464	369	345	322	301	279	.33
25	589	550	507	476	446	354	331	309	289	268	.36
26	567	529	488	458	428	340	319	297	277	258	.39
27	546	509	470	441	413	328	307	286	267	248	.42
28	526	491	453	425	398	316	296	276	258	240	.45
29	508	474	437	410	384	305	286	266	249	231	.48
30	491	458	423	397	371	295	276	257	240	224	.52
32	461	430	396	372	348	277	259	241	225	210	.59
34	433	404	373	350	328	260	244	227	212	197	.66
36	409	382	352	331	310	246	230	215	200	186	.75
38	388	362	334	313	293	233	218	203	190	177	.83
40	368	344	317	298	279	221	207	193	180	168	.92
42	351	327	302	283	265	211	197	184	172	160	1.01
44	335	313	288	271	253	201	188	176	164	152	1.11
46	320	299	276	259	242	192	180	168	157	146	1.22
48	307	287	264	248	232	184	173	161	150	140	1.32
50	295	275	254	238	223	177	166	154	144	134	1.44
52	283	264	244	229	214	170	159	149	139	129	1.55
54	273	255	235	220	206	164	153	143	134	124	1.68
56	263	246	227	213	199	158	148	138	129	120	1.80
58	254	237	219	205	192	153	143	133	124	116	1.93
60	246	229	211	197	186	148	138	129	120	112	2.07
62	238	222	205	192	180	143	134	125	116	108	2.21
64	230	215	198	186	174	138	129	121	113	105	2.35
66	223	208	192	181	169	134	126	117	109	102	2.50
68	217	202	187	175	164	130	122	114	106	99	2.66
70	211	196	181	170	159	126	118	110	103	96	2.82
72	205	191	176	165	155	123	115	107	100	93	2.98

PROPERTIES AND REACTION VALUES

	300	280	260	245	230	194	182	170	160	150	
S $in.^3$	1105.1	1031.2	951.1	892.5	835.5	663.6	621.2	579.1	541.0	502.9	
V kips	451	420	398	376	357	365	342	320	306	291	See Page 173
R kips	143	132	123	114	108	104	97	89	84	80	
G kips	22.7	21.2	20.3	19.2	18.4	18.5	17.4	16.3	15.7	15.0	
N in.	17.1	17.1	17.1	17.1	17.1	17.6	17.6	17.7	17.6	17.6	

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BEAMS

WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot						Deflection Inches
	33 x 15¾			33 x 11½			
	240	220	200	152	141	130	
d/bt	1.51	1.65	1.82	2.74	3.01	3.36	
L_u	33	30	27	18	16.5	15	
10						498	.06
11				554	524	490	.08
12				540	496	449	.09
13				499	458	415	.11
14	724	670	614	463	426	385	.12
15	721	658	595	432	397	359	.14
16	676	617	558	405	372	337	.16
17	636	581	525	382	350	317	.18
18	601	549	496	360	331	300	.20
19	569	520	470	341	314	284	.23
20	541	494	446	324	298	269	.25
21	515	470	425	309	284	257	.28
22	492	449	406	295	271	245	.30
23	470	429	388	282	259	234	.33
24	451	412	372	270	248	225	.36
25	433	395	357	259	238	216	.39
26	416	380	343	249	229	207	.42
27	401	366	331	240	221	199	.46
28	386	353	319	232	213	193	.49
29	373	341	308	224	205	186	.53
30	361	329	298	216	199	179	.56
32	338	309	279	203	186	168	.64
34	318	291	263	191	175	159	.73
36	300	274	248	180	166	150	.81
38	285	260	235	171	157	142	.91
40	270	247	223	162	149	135	1.00
42	258	235	213	154	142	128	1.11
44	246	224	203	147	135	122	1.21
46	235	215	194	141	130	117	1.33
48	225	206	186	135	124	112	1 45
50	216	198	179	130	119	108	1.57
52	208	190	172	125	115	104	1.70
54	200	183	165	120	110	100	1.83
56	193	176	159	116	106	96	1.97
58	187	170	154	112	103	93	2.11
60	180	165	149	108	99	90	2.26
62	175	159	144	105	96	87	2.41
64	169	154	140	101	93	84	2.57
66	164	150	135	98	90	82	2.73
68	159	145	131	95	88	79	2.90

PROPERTIES AND REACTION VALUES

	240	220	200	152	141	130	
S in.³	811.1	740.6	669.6	486.4	446.8	404.8	See Page 173
V kips	362	335	307	277	262	249	
R kips	118	108	98	82	76	72	
G kips	19.9	18.6	17.2	15.2	14.5	13.9	
N in.	15.7	15.7	15.7	16.3	16.3	16.3	

BEAMS

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WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot							Deflection Inches
	30 x 15			30 x 10½				
	210	190	172	132	124	116	108	
d/bt	1.53	1.69	1.87	2.87	3.08	3.36	3.74	
L_u	32.5	29.5	26.5	17.5	16	15	13	
9						440	424	.06
10						437	399	.07
				484	458			
11				460	430	397	363	.08
12				422	394	364	332	.10
13			508	389	364	336	307	.12
14	612	556	503	362	338	312	285	.14
15	578	521	470	338	315	292	266	.16
16	542	488	440	316	296	273	249	.18
17	510	460	414	298	278	257	235	.20
18	481	434	391	281	263	243	222	.22
19	456	411	371	267	249	230	210	.25
20	433	391	352	253	236	219	200	.28
21	413	372	335	241	225	208	190	.30
22	394	355	320	230	215	199	181	.33
23	377	340	306	220	206	190	173	.37
24	361	326	294	211	197	182	166	.40
25	347	313	282	203	189	175	160	.43
26	333	301	271	195	182	168	153	.47
27	321	289	261	188	175	162	148	.50
28	310	279	252	181	169	156	143	.54
29	299	270	243	175	163	151	138	.58
30	289	261	235	169	158	146	133	.62
32	271	244	220	158	148	137	125	.71
34	255	230	207	149	139	129	117	.80
36	241	217	196	141	131	122	111	.89
38	228	206	185	133	124	115	105	1.00
40	217	195	176	127	118	109	100	1.10
42	206	186	168	121	113	104	95	1.22
44	197	178	160	115	107	99	91	1.34
46	188	170	153	110	103	95	87	1.46
48	181	163	147	106	99	91	83	1.59
50	173	156	141	101	95	88	80	1.72
52	167	150	135	97	91	84	77	1.87
54	161	145	130	94	88	81	74	2.01
56	155	140	126	90	84	78	71	2.16
58	149	135	121	87	82	75	69	2.32
60	144	130	117	84	79	73	67	2.48
62	140	126	114	82	76	71	64	2.65

PROPERTIES AND REACTION VALUES

	210	190	172	132	124	116	108	
S in.³	649.9	586.1	528.2	379.7	354.6	327.9	299.2	See Page 173
V kips	306	278	254	242	229	220	212	
R kips	108	97	87	77	72	69	66	
G kips	18.6	17.0	15.7	14.8	14.0	13.5	13.2	
N in.	14.2	14.1	14.1	14.7	14.7	14.7	14.7	

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BEAMS

WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot						Deflection Inches
	27 x 14			27 x 10			
	177	160	145	114	102	94	
d/bt	1.63	1.80	1.97	2.91	3.27	3.61	
L_u	30.5	27.5	25	17	15	13.5	
9				404	364	344	.06
10				399	356	324	.08
11				363	323	294	.09
12	514	464	420	332	296	270	.11
13	505	455	413	307	274	249	.13
14	469	423	384	285	254	231	.15
15	438	395	358	266	237	216	.17
16	411	370	336	249	222	202	.20
17	387	348	316	235	209	190	.22
18	365	329	298	222	197	180	.25
19	346	312	283	210	187	170	.28
20	329	296	269	200	178	162	.31
21	313	282	256	190	169	154	.34
22	299	269	244	181	162	147	.37
23	286	257	234	173	154	141	.41
24	274	247	224	166	148	135	.44
25	263	237	215	160	142	129	.48
26	253	228	207	153	137	125	.52
27	243	219	199	148	132	120	.56
28	235	211	192	143	127	116	.60
29	227	204	185	138	123	112	.64
30	219	197	179	133	119	108	.69
31	212	191	173	129	115	104	.74
32	205	185	168	125	111	101	.79
33	199	179	163	121	108	98	.83
34	193	174	158	117	104	95	.89
35	188	169	154	114	101	92	.94
36	183	164	149	111	99	90	.99
37	178	160	145	108	96	87	1.05
38	173	156	141	105	93	85	1.11
39	169	152	138	102	91	83	1.17
40	164	148	134	100	89	81	1.23
42	157	141	128	95	85	77	1.35
44	149	135	122	91	81	74	1.48
46	143	129	117	87	77	70	1.62
48	137	123	112	83	74	67	1.77
50	131	118	108	80	71	65	1.92
52	126	114	103	77	68	62	2.07
54	122	110	100	74	66	60	2.24
56	117	106	96	71	63	58	2.40

PROPERTIES AND REACTION VALUES

S in.^{3}	492.8	444.5	402.9	299.2	266.3	242.8	
V kips	257	232	210	202	182	172	
R kips	98	88	78	70	63	58	See Page 173
G kips	17.4	15.8	14.4	13.7	12.4	11.8	
N in.	12.7	12.6	12.6	13.1	13.1	13.1	

BEAMS

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WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot 24 x 14			24 x 12			24 x 9			Deflection Inches
	160	145	130	120	110	100	94	84	76	
d/bt	1.55	1.71	1.93	2.16	2.34	2.58	3.07	3.47	3.90	
L_u	32	29	26	23	21	19	16	14.5	12.5	
8								294	274	.06
9							326	291	260	.07
10							295	262	234	.09
11				352	320	292	268	238	213	.10
12		388	356	332	305	277	245	218	195	.12
13	422	382	339	307	281	255	227	202	180	.15
14	394	355	315	285	261	237	210	187	167	.17
15	368	331	294	266	244	221	196	174	156	.19
16	345	311	276	249	229	207	184	164	146	.22
17	324	292	259	235	215	195	173	154	138	.25
18	306	276	245	222	203	184	164	145	130	.28
19	290	261	232	210	193	175	155	138	123	.31
20	276	248	221	199	183	166	147	131	117	.35
21	263	236	210	190	174	158	140	125	112	.38
22	251	226	200	181	166	151	134	119	106	.42
23	240	216	192	173	159	144	128	114	102	.46
24	230	207	184	166	153	138	123	109	98	.50
25	221	199	176	160	146	133	118	105	94	.54
26	212	191	170	153	141	128	113	101	90	.58
27	204	184	163	148	136	123	109	97	87	.63
28	197	177	158	142	131	119	105	93	84	.68
29	190	171	152	138	126	114	102	90	81	.73
30	184	166	147	133	122	111	98	87	78	.78
31	178	160	142	129	118	107	95	84	75	.83
32	172	155	138	125	114	104	92	82	73	.88
33	167	151	134	121	111	101	89	79	71	.94
34	162	146	130	117	108	98	87	77	69	1.00
35	158	142	126	114	105	95	84	75	67	1.06
36	153	138	123	111	102	92	82	73	65	1.12
37	149	134	119	108	99	90	80	71	63	1.18
38	145	131	116	105	96	87	78	69	61	1.25
39	141	127	113	102	94	85	76	67	60	1.31
40	138	124	110	100	92	83	74	65	58	1.38
42	131	118	105	95	87	79	70	62	56	1.52
44	125	113	100	91	83	75	67	59	53	1.67
46	120	108	96	87	80	72	64	57	51	1.82
48	115	104	92	83	76	69	61	55	49	1.99
50	110	99	88	80	73	66	59	52	47	2.16

PROPERTIES AND REACTION VALUES

S in.^{3}	413.5	372.5	330.7	299.1	274.4	248.9	220.9	196.3	175.4	
V kips	211	194	178	176	160	146	163	147	137	
R kips	87	78	71	69	63	57	61	55	50	See Page 173
G kips	15.7	14.6	13.6	13.3	12.2	11.2	12.4	11.3	10.6	
N in.	11.4	11.4	11.4	11.5	11.5	11.4	11.7	11.7	11.7	

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BEAMS

WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot								Deflection Inches
	21 x 13			21 x 9		21 x 8¼			
	142	127	112	96	82	73	68	62	
d/bt	1.49	1.65	1.87	2.50	2.93	3.46	3.73	4.15	
L_u	33.5	30	27	20	17	14.5	13.5	12	
7							236	218	.05
8				316	270	**251**	233	211	.06
9				293	249	223	207	187	.08
10				264	224	201	187	169	.10
11	368	326	288	240	204	183	170	153	.12
12	352	316	277	220	187	167	155	141	.14
13	325	292	256	203	172	155	144	130	.17
14	302	271	238	188	160	144	133	120	.19
15	282	253	222	176	149	134	124	112	.22
16	264	237	208	165	140	126	117	105	.25
17	249	223	196	155	132	118	110	99	.29
18	235	211	185	146	124	112	104	94	.32
19	223	199	175	139	118	106	98	89	.36
20	212	189	166	132	112	101	93	84	.39
21	201	180	159	126	107	96	89	80	.43
22	192	172	151	120	102	91	85	77	.48
23	184	165	145	115	97	87	81	73	.52
24	176	158	139	110	93	84	78	70	.57
25	169	152	133	105	90	80	75	67	.62
26	163	146	128	101	86	77	72	65	.67
27	157	140	123	98	83	74	69	62	.72
28	151	135	119	94	80	72	67	60	.77
29	146	131	115	91	77	69	64	58	.83
30	141	126	111	88	75	67	62	56	.89
31	136	122	107	85	72	65	60	54	.95
32	132	118	104	82	70	63	58	53	1.01
33	128	115	101	80	68	61	57	51	1.07
34	124	111	98	78	66	59	55	50	1.14
35	121	108	95	75	64	57	53	48	1.21
36	118	105	93	73	62	56	52	47	1.28
37	114	102	90	71	61	54	50	45	1.35
38	111	100	88	69	59	53	49	44	1.42
39	109	97	85	68	57	52	48	43	1.50
40	106	95	83	66	56	50	47	42	1.58
41	103	92	81	64	55	49	46	41	1.66
42	101	90	79	63	53	48	44	40	1.74
43	98	88	77	61	52	47	43	39	1.82
44	96	86	76	60	51	46	42	38	1.91

PROPERTIES AND REACTION VALUES

S in.³	317.2	284.1	249.6	197.6	168.0	150.7	139.9	126.4	See Page 173
V kips	184	163	144	158	135	126	118	109	
R kips	85	74	65	70	59	53	49	45	
G kips	15.8	14.1	12.7	13.8	12.0	10.9	10.3	9.6	
N in.	9.7	9.8	9.8	9.9	9.9	10.2	10.2	10.2	

BEAMS

18

WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot										Deflection Inches
	18 x 11¾			18 x 8¾				18 x 7½			
	114	105	96	85	77	70	64	60	55	50	
d/bt	1.58	1.71	1.86	2.28	2.49	2.74	2.99	3.48	3.82	4.22	
L_u	31.5	29	27	22	20	18	16.5	14.5	13	12	
7								198	184	168	.06
8				250	224	206	188	179	164	148	.07
9				231	210	190	173	160	146	132	.09
10	286	264	242	208	189	171	156	144	131	119	.12
11	267	245	224	189	172	155	142	130	119	108	.14
12	245	225	205	173	157	142	130	120	109	99	.17
13	226	207	189	160	145	132	120	110	101	91	.19
14	210	193	176	149	135	122	111	102	94	85	.23
15	196	180	164	139	126	114	104	96	87	79	.26
16	183	169	154	130	118	107	98	90	82	74	.29
17	173	159	145	122	111	101	92	84	77	70	.33
18	163	150	137	116	105	95	87	80	73	66	.37
19	155	142	129	110	99	90	82	75	69	63	.42
20	147	135	123	104	95	86	78	72	66	59	.46
21	140	128	117	99	90	81	74	68	62	57	.51
22	133	123	112	95	86	78	71	65	60	54	.56
23	128	117	107	91	82	74	68	62	57	52	.61
24	122	112	103	87	79	71	65	60	55	49	.66
25	117	108	98	83	76	68	62	57	52	48	.72
26	113	104	95	80	73	66	60	55	50	46	.78
27	109	100	91	77	70	63	58	53	49	44	.84
28	105	96	88	74	68	61	56	51	47	42	.90
29	101	93	85	72	65	59	54	49	45	41	.97
30	98	90	82	69	63	57	52	48	44	40	1.03
31	95	87	79	67	61	55	50	46	42	38	1.11
32	92	84	77	65	59	53	49	45	41	37	1.18
33	89	82	75	63	57	52	47	43	40	36	1.25
34	86	79	72	61	56	50	46	42	39	35	1.33
35	84	77	70	60	54	49	45	41	37	34	1.41
36	82	75	68	58	53	48	43	40	36	33	1.49
37	79	73	67	56	51	46	42	39	35	32	1.57
38	77	71	65	55	50	45	41	38	35	31	1.66

PROPERTIES AND REACTION VALUES

S in.³	220.1	202.2	184.4	156.1	141.7	128.2	117.0	107.8	98.2	89.0	See Page 173
V kips	143	132	121	125	112	103	94	99	92	84	
R kips	74	68	62	63	56	51	46	47	43	39	
G kips	14.3	13.3	12.3	12.6	11.4	10.5	9.7	10.0	9.4	8.6	
N in.	8.3	8.3	8.3	8.4	8.5	8.4	8.4	8.7	8.7	8.7	

16 BEAMS

WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot										Deflection Inches
	16 x 11½		16 x 8½				16 x 7				
	96	88	78	71	64	58	50	45	40	36	
d/bt	1.62	1.77	2.17	2.38	2.63	2.91	3.66	4.07	4.54	5.30	
L_u	31	28	23	21	19	17	13.5	12	11	9.5	
6							160	146	128	124	.05
7			224	204	184	168	154	138	123	107	.06
8			213	193	174	157	135	121	107	94	.08
9	228	212	189	172	154	139	120	107	95	83	.11
10	222	202	170	155	139	126	108	97	86	75	.13
11	201	183	155	141	126	114	98	88	78	68	.16
12	185	168	142	129	116	105	90	80	72	63	.19
13	170	155	131	119	107	97	83	74	66	58	.22
14	158	144	122	110	99	90	77	69	61	54	.25
15	148	135	114	103	93	84	72	64	57	50	.29
16	138	126	107	97	87	78	67	60	54	47	.33
17	130	119	100	91	82	74	63	57	51	44	.37
18	123	112	95	86	77	70	60	54	48	42	.42
19	117	106	90	81	73	66	57	51	45	40	.47
20	111	101	85	77	70	63	54	48	43	38	.52
21	106	96	81	74	66	60	51	46	41	36	.57
22	101	92	78	70	63	57	49	44	39	34	.63
23	96	88	74	67	60	55	47	42	37	33	.68
24	92	84	71	64	58	52	45	40	36	31	.75
25	89	81	68	62	56	50	43	39	34	30	.81
26	85	78	66	59	53	48	41	37	33	29	.87
27	82	75	63	57	52	47	40	36	32	28	.94
28	79	72	61	55	50	45	38	35	31	27	1.01
29	76	70	59	53	48	43	37	33	30	26	1.09
30	74	67	57	52	46	42	36	32	29	25	1.16
31	71	65	55	50	45	41	35	31	28	24	1.24
32	69	63	53	48	43	39	34	30	27	24	1.32
33	67	61	52	47	42	38	33	29	26	23	1.41
34	65	59	50	46	41	37	32	28	25	22	1.50
PROPERTIES AND REACTION VALUES											
S $in.^3$	166.1	151.3	127.8	115.9	104.2	94.1	80.7	72.4	64.4	56.3	See Page 173
V kips	114	106	112	102	92	84	80	73	64	62	
R kips	66	61	64	57	51	46	42	38	33	32	
G kips	12.8	12.1	12.7	11.7	10.6	9.8	9.1	8.3	7.4	7.2	
N in.	7.2	7.3	7.3	7.4	7.4	7.3	7.7	7.7	7.7	7.6	

BEAMS 14

WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot										Deflection Inches
	14 x 14½					14 x 12		14 x 10			
	119	111	103	95	87	84	78	74	68	61	
d/bt	1.06	1.13	1.20	1.30	1.40	1.52	1.63	1.80	1.95	2.16	
L_u	47	44	41	38	35.5	33	30.5	28	25.5	23	
9								166	152	136	.12
10						166	156	150	137	123	.15
11	214	202	184	170		159	147	136	125	112	.18
12	210	196	182	167	152	145	135	125	114	102	.21
13	194	181	168	155	142	134	124	115	106	95	.25
14	180	168	156	143	132	125	115	107	98	88	.29
15	168	157	145	134	123	116	108	100	92	82	.33
16	158	147	136	126	115	109	101	94	86	77	.38
17	149	138	128	118	108	103	95	88	81	72	.43
18	140	131	121	112	102	97	90	83	76	68	.48
19	133	124	115	106	97	92	85	79	72	65	.53
20	126	118	109	100	92	87	81	75	69	62	.59
21	120	112	104	96	88	83	77	71	65	59	.65
22	115	107	99	91	84	79	73	68	62	56	.72
23	110	102	95	87	80	76	70	65	60	53	.78
24	105	98	91	84	77	73	67	62	57	51	.85
25	101	94	87	80	74	70	65	60	55	49	.92
26	97	90	84	77	71	67	62	58	53	47	1.00
27	94	87	81	74	68	65	60	56	51	46	1.08
28	90	84	78	72	66	62	58	54	49	44	1.16
29	87	81	75	69	64	60	56	52	47	42	1.24
30	84	78	73	67	61	58	54	50	46	41	1.33
31	81	76	70	65	59	56					
32	79	73	68	63	57	54					
33	76	71	66	61	56	53					
34	74	69	64	59	54						
35	72	67	62	57	53						
36	70	65	60	56	51						
37	68	63	59	54							
38	66	62	57	53							

PROPERTIES AND REACTION VALUES

	119	111	103	95	87	84	78	74	68	61	
S in.^{3}	189.4	176.3	163.6	150.6	138.1	130.9	121.1	112.3	103.0	92.2	See Page 173
V kips	107	101	92	85	76	83	78	83	76	68	
R kips	69	65	59	55	49	53	49	53	48	43	
G kips	13.7	13.0	11.9	11.2	10.1	10.8	10.3	10.8	10.0	9.1	
N in.	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	

14

BEAMS

WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot						Deflection Inches
	14 x 8			14 x 6¾			
	53	48	43	38	34	30	
d/bt	2.63	2.90	3.24	4.06	4.58	5.37	
L_u	19	17	15.5	12.5	11	9.5	
5						98	.04
6				116	104	93	.05
7	134	122	110	104	92	80	.07
8	130	117	105	91	81	70	.10
9	115	104	93	81	72	62	.12
10	104	94	84	73	65	56	.15
11	94	85	76	66	59	51	.18
12	86	78	70	61	54	46	.21
13	80	72	64	56	50	43	.25
14	74	67	60	52	46	40	.29
15	69	62	56	49	43	37	.33
16	65	59	52	46	40	35	.38
17	61	55	49	43	38	33	.43
18	58	52	46	40	36	31	.48
19	55	49	44	38	34	29	.53
20	52	47	42	36	32	28	.59
21	49	45	40	35	31	27	.65
22	47	43	38	33	29	25	.72
23	45	41	36	32	28	24	.78
24	43	39	35	30	27	23	.85
25	42	37	33	29	26	22	.92
26	40	36	32	28	25	21	1.00
27	38	35	31	27	24	21	1.08
28	37	33	30	26	23	19.9	1.16
29	36	32	29	25	22	19.2	1.24
30	35	31	28	24	22	18.6	1.33
PROPERTIES AND REACTION VALUES							
S in.³	77.8	70.2	62.7	54.6	48.5	41.8	See Page 173
V kips	67	61	55	58	52	49	
R kips	42	38	34	34	31	28	
G kips	8.9	8.1	7.4	7.5	6.9	6.5	
N in.	6.3	6.3	6.3	6.7	6.6	6.6	

BEAMS

12

WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot						Deflection Inches
	12 x 12				12 x 10		
	85	79	72	65	58	53	
d/bt	1.29	1.39	1.52	1.67	1.90	2.09	
L_u	38	36	33	30	26	24	
8						108	.11
9	160	152	138	122	114	105	.14
10	154	143	130	117	104	94	.17
11	140	130	118	107	95	86	.21
12	129	119	108	98	87	79	.25
13	119	110	100	90	80	73	.29
14	110	102	93	84	74	67	.34
15	103	95	87	78	69	63	.39
16	96	89	81	73	65	59	.44
17	91	84	77	69	61	56	.50
18	86	79	72	65	58	52	.56
19	81	75	68	62	55	50	.62
20	77	71	65	59	52	47	.69
21	74	68	62	56	50	45	.76
22	70	65	59	53	47	43	.83
23	67	62	57	51	45	41	.91
24	64	60	54	49	43	39	.99
25	62	57	52	47	42	38	1.08
26	59	55	50	45			
27	57	53	48	43			
28	55	51	46	42			
29	53	49	45	40			
30	51	48	43	39			
31	50	46	42				
32	48	45	41				
33	47	43	39				
34	45	42					
35	44	41					
36	43	40					
37	42						
38	41						

PROPERTIES AND REACTION VALUES

	85	79	72	65	58	53	
S in.^{3}	115.7	107.1	97.5	88.0	78.1	70.7	See Page 173
V kips	80	76	69	61	57	54	
R kips	58	54	49	44	41	39	
G kips	11.9	11.3	10.3	9.4	8.6	8.3	
N in.	5.4	5.4	5.4	5.4	5.4	5.3	

12

BEAMS

WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot						Deflection Inches
	12 x 8			12 x 6½			
	50	45	40	36	31	27	
d/bt	2.35	2.60	2.89	3.45	3.98	4.60	
L_u	21	19	17.5	14.5	12.5	10.5	
6				98	82	74	.06
7	118	106	92	87	75	65	.08
8	108	97	87	77	65	57	.11
9	96	86	77	68	58	50	.14
10	86	78	69	61	52	45	.17
11	78	71	63	56	48	41	.21
12	72	65	58	51	44	38	.25
13	66	60	53	47	40	35	.29
14	62	55	49	44	37	32	.34
15	58	52	46	41	35	30	.39
16	54	49	43	38	33	28	.44
17	51	46	41	36	31	27	.50
18	48	43	38	34	29	25	.56
19	45	41	36	32	27	24	.62
20	43	39	35	31	26	23	.69
21	41	37	33	29	25	22	.76
22	39	35	32	28	24	21	.83
23	38	34	30	27	23	20	.91
24	36	32	29	26	22	19	.99
25	35	31	28	25	21	18	1.08

PROPERTIES AND REACTION VALUES

S in.^{3}	64.7	58.2	51.9	45.9	39.4	34.1	See Page 173
V kips	59	53	46	49	41	37	
R kips	42	38	33	33	28	25	
G kips	8.9	8.1	7.1	7.3	6.35	5.75	
N in.	5.4	5.4	5.3	5.7	5.6	5.7	

BEAMS

10

WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot										Deflection Inches
	10 x 10				10 x 8			10 x 5¾			
	66	60	54	49	45	39	33	29	25	21	
d/bt	1.37	1.49	1.63	1.79	2.04	2.36	2.83	3.52	4.08	5.07	
L_u	36	33.5	30.5	28	24.5	21	17.5	14	12	10	
4										62	.03
5								76	66	57	.05
6						82	74	68	59	48	.07
7	124				92	80	67	59	50	41	.10
8	123	110	96	88	82	70	58	51	44	36	.13
9	109	99	90	81	73	62	52	46	39	32	.17
10	98	90	81	73	66	56	47	41	35	29	.21
11	89	81	73	66	60	51	42	37	32	26	.25
12	82	75	67	61	55	47	39	34	29	24	.30
13	76	69	62	56	50	43	36	32	27	22	.35
14	70	64	58	52	47	40	33	29	25	21	.41
15	66	60	54	49	44	37	31	27	23	19.1	.47
16	61	56	50	46	41	35	29	26	22	17.9	.53
17	58	53	47	43	39	33	28	24	21	16.9	.60
18	55	50	45	40	36	31	26	23	19	15.9	.67
19	52	47	42	38	35	30	25	22	18	15.1	.75
20	49	45	40	36	33	28	23	21	17	14.3	.83
21	47	43	38	35	31	27	22	19.6	16	13.7	.91
22	44	41	36	33	30						
23	42	39	35	32	28						
24	41	37	33	30	27						
25	39	36	32	29							
26	38	34	31	28							
27	36	33	30	27							
28	35	32	29	26							
29	34	31	28								
30	32	30	27								

PROPERTIES AND REACTION VALUES

S in.³	73.7	67.1	60.4	54.6	49.1	42.2	35.0	30.8	26.4	21.5	See Page 173
V kips	62	55	48	44	46	41	37	38	33	31	
R kips	52	47	41	37	39	35	31	30	26	24	
G kips	11.0	10.0	8.8	8.2	8.4	7.65	7.0	6.9	6.05	5.8	
N in.	4.4	4.4	4.4	4.4	4.4	4.3	4.3	4.7	4.7	4.7	

8 BEAMS

WF BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see page 202.

Span in Feet	Nominal Depth and Width—Weight per Foot						Deflection Inches
	8 x 8		8 x 6½		8 x 5¼		
	35	31	28	24	20	17	
d/bt	2.05	2.31	2.66	3.07	4.08	4.95	
L_u	24	21.5	18.5	16	12	10	
3						48	.02
4					52	47	.04
5			60	50	45	38	.07
6	66	60	54	46	38	31	.09
7	59	52	46	40	32	27	.13
8	52	46	40	35	28	24	.17
9	46	41	36	31	25	21	.21
10	42	37	32	28	22.6	18.8	.26
11	38	33	29	25	20.6	17.1	.31
12	35	30	27	23	18.9	15.7	.37
13	32	28	25	21	17.4	14.5	.44
14	30	26	23	19.8	16.2	13.4	.51
15	28	24	21	18.5	15.1	12.5	.58
16	26	23	20	17.3	14.2	11.7	.66
17	24	22	19	16.3	13.3	11.1	.75
18	23	20	18				
19	22	19	17				
20	21	18					
21	20	17					
22	19	16					
23	18						
24	17						

PROPERTIES AND REACTION VALUES

	35	31	28	24	20	17	
S in.³	31.1	27.4	24.3	20.8	17.0	14.1	See Page 173
V kips	33	30	30	25	26	24	
R kips	33	30	30	25	25	23	
G kips	7.6	6.9	6.85	5.9	5.95	5.5	
N in.	3.5	3.5	3.6	3.5	3.7	3.7	

BEAMS — 24-20

AMERICAN STANDARD BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see pages 172-3.

Span in Feet	Nominal Depth and Width—Weight per Foot										
	24 x 7⅞		24 x 7			D	20 x 7		20 x 6¼		D
	120	105.9	100	90	79.9		95	85	75	65.4	
d/bt	2.71	2.76	3.81	3.87	3.94		3.03	3.09	3.97	4.05	
L_u	18.5	18	13	13	12.5		16.5	16	12.5	12	
5			466				416	340	334		.03
6	498		439	390		.03	356	334	281	260	.04
7	478		376	354	312	.04	303	286	241	223	.05
8	418	390	329	310	290	.06	267	250	211	195	.07
9	372	347	293	275	258	.07	237	223	187	173	.08
10	335	312	264	248	232	.09	213	200	169	156	.10
11	304	284	240	225	211	.10	194	182	153	142	.13
12	279	260	220	206	193	.12	178	167	140	130	.15
13	257	240	203	191	178	.15	164	154	130	120	.18
14	239	223	188	177	166	.17	152	143	120	111	.20
15	223	208	176	165	155	.19	142	134	112	104	.23
16	209	195	165	155	145	.22	133	125	105	97	.27
17	197	184	155	146	136	.25	126	118	99	92	.30
18	186	174	146	138	129	.28	118	111	94	87	.34
19	176	164	139	130	122	.31	112	105	89	82	.37
20	167	156	132	124	116	.35	107	100	84	78	.41
21	159	149	126	118	110	.38	102	95	80	74	.46
22	152	142	120	113	105	.42	97	91	77	71	.50
23	145	136	115	108	101	.46	93	87	73	68	.55
24	139	130	110	103	97	.50	89	84	70	65	.60
25	134	125	105	99	93	.54	85	80	67	62	.65
26	129	120	101	95	89	.58	82	77	65	60	.70
27	124	116	98	92	86	.63	79	74	62	58	.75
28	120	112	94	89	83	.68	76	72	60	56	.81
29	115	108	91	85	80	.73	74	69	58	54	.87
30	112	104	88	83	77	.78	71	67	56	52	.93
31	108	101	85	80	75	.83	69	65	54	50	.99
32	105	98	82	77	73	.88	67	63	53	49	1.06
33	101	95	80	75	70	.94	65	61	51	47	1.13
34	98	92	78	73	68	1.00	63	59	50	46	1.20
35	96	89	75	71	66	1.06	61	57	48	45	1.27
36	93	87	73	69	64	1.12	59	56	47	43	1.34
37	90	84	71	67	63	1.18	58	54	46	42	1.42
38	88	82	69	65	61	1.25	56	53	44	41	1.49
39	86	80	68	64	60	1.31	55	51	43	40	1.57
40	84	78	66	62	58	1.38	53	50	42	39	1.66
42	80	74	63	59	55	1.52	51	48	40	37	1.83
44	76	71	60	56	53	1.67					
46	73	68	57	54	50	1.82					
48	70	65	55	52	48	1.99					
50	67	63	53	50	46	2.16					

Note:
D = Deflection in Inches.

PROPERTIES AND REACTION VALUES

	120	105.9	100	90	79.9		95	85	75	65.4	
S in.³	250.9	234.3	197.6	185.8	173.9	See Page 173	160.0	150.2	126.3	116.9	See Page 173
V kips	249	195	233	195	156		208	170	167	130	
R kips	104	82	92	77	62		101	82	78	61	
G kips	19.2	15.0	17.9	15.0	12.0		19.2	15.7	15.4	12.0	
N in.	11.1	11.1	11.4	11.4	11.4		9.1	9.1	9.3	9.3	

18-15-12

BEAMS

AMERICAN STANDARD BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see pages 172-3.

Span in Feet	18 x 6			15 x 5½			12 x 5¼		12 x 5		
	70	54.7	D	50	42.9	D	50	40.8	35	31.8	D
d/bt	4.17	4.35		4.28	4.39		3.32	3.47	4.34	4.41	
L_u	12	11.5		11.5	11		15	14.5	11.5	11.5	
3							214		134		.02
4	332			214	160	.02	168	144	126	110	.03
5	272	216	.03	171	157	.03	134	120	101	96	.04
6	226	196	.04	143	131	.05	112	100	84	80	.06
7	194	168	.06	122	112	.07	96	85	72	69	.08
8	170	147	.07	107	98	.09	84	75	63	60	.11
9	151	131	.09	95	87	.11	75	66	56	53	.14
10	136	118	.12	86	79	.14	67	60	50	48	.17
11	124	107	.14	78	71	.17	61	54	46	44	.21
12	113	98	.17	71	65	.20	56	50	42	40	.25
13	105	91	.19	66	60	.23	52	46	39	37	.29
14	97	84	.23	61	56	.27	48	43	36	34	.34
15	91	79	.26	57	52	.31	45	40	34	32	.39
16	85	74	.29	54	49	.35	42	37	32	30	.44
17	80	69	.33	50	46	.40	40	35	30	28	.50
18	76	66	.37	48	44	.45	37	33	28	27	.56
19	72	62	.42	45	41	.50	35	31	27	25	.62
20	68	59	.46	43	39	.55	34	30	25	24	.69
21	65	56	.51	41	37	.61	32	28	24	23	.76
22	62	54	.56	39	36	.67	31	27	23	22	.83
23	59	51	.61	37	34	.73	29	26	22	21	.91
24	57	49	.66	36	33	.79	28	25	21	20	.99
25	54	47	.72	34	31	.86	27	24	20	19.2	1.08
26	52	45	.78	33	30	.93					
27	50	44	.84	32	29	1.01					
28	49	42	.90	31	28	1.08					
29	47	41	.97	30	27	1.16					
30	45	39	1.03	29	26	1.24					
31	44	38	1.11	28	25	1.33					
32	43	37	1.18	27	25	1.41					
33	41	36	1.25								
34	40	35	1.33								
35	39	34	1.41								
36	38	33	1.49								
37	37	32	1.57								
38	36	31	1.66								

Note:
D = Deflection in Inches.

PROPERTIES AND REACTION VALUES

	70	54.7		50	42.9		50	40.8	35	31.8	
S in.³	101.9	88.4	See Page 173	64.2	58.9	See Page 173	50.3	44.8	37.8	36.0	See Page 173
V kips	166	108		107	80		107	72	67	55	
R kips	83	54		63	47		79	53	48	39	
G kips	17.1	11.0		13.2	9.8		16.5	11.0	10.3	8.4	
N in.	8.4	8.4		6.9	6.9		5.2	5.2	5.4	5.4	

BEAMS

10-8-7

AMERICAN STANDARD BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see pages 172-3.

Span in Feet	10 x 4¾			8 x 4			7 x 3¾		
	35.0	25.4	D	23.0	18.4	D	20.0	15.3	D
d/bt	4.12	4.37		4.51	4.71		4.62	4.88	
L_u	12	11.5		11	10.5		11	10	
2	154		.01	92		.01	82		.01
3	130		.02	71	56	.02	53	46	.03
4	97	80	.03	53	47	.04	40	35	.05
5	78	65	.05	43	38	.07	32	28	.07
6	65	54	.07	36	32	.09	27	23	.11
7	56	47	.10	31	27	.13	23	19.8	.15
8	49	41	.13	27	24	.17	20	17.3	.19
9	43	36	.17	24	21	.21	17.8	15.4	.24
10	39	33	.21	21	18.9	.26	16.0	13.9	.30
11	35	30	.25	19.4	17.2	.31	14.5	12.6	.36
12	32	27	.30	17.8	15.8	.37	13.3	11.6	.43
13	30	25	.35	16.4	14.6	.44	12.3	10.7	.50
14	28	23	.41	15.2	13.5	.51	11.4	9.9	.58
15	26	22	.47	14.2	12.6	.58	10.7	9.2	.67
16	24	20	.53	13.3	11.8	.66			
17	23	19.1	.60	12.5	11.1	.73			
18	22	18.1	.67						
19	21	17.1	.75						
20	19.5	16.3	.83						
21	18.5	15.5	.91						

Note:
D = Deflection in Inches.

PROPERTIES AND REACTION VALUES

S in.³	29.2	24.4	See Page 173	16.0	14.2	See Page 173	12.0	10.4	See Page 173
V kips	77	40		46	28		41	23	
R kips	64	34		46	28		*47*	*26*	
G kips	14.3	7.4		10.6	6.5		10.8	6.0	
N in.	4.4	4.4		3.5	3.5		3.0	3.0	

Values of R in italics exceed maximum web shear V.

6-5-4-3

BEAMS

AMERICAN STANDARD BEAMS

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see pages 172-3.

Span in Feet	Nominal Depth and Width—Weight per Foot											
	6 x 3⅜			5 x 3			4 x 2¾			3 x 2⅜		
	17.25	12.5	D	14.75	10.0	D	9.5	7.7	D	7.5	5.7	D
d/bt	4.69	5.02		4.67	5.11		4.89	5.13		4.60	4.95	
L_u	10.5	10		10.5	10		10	9.5		11	10	
2		36	.01		27	.02						
3	39	32	.03	27	21	.04	14.7	13.3	.05	8.4	7.6	.06
4	29	24	.06	20	16.0	.07	11.0	10.0	.08	6.3	5.7	.11
5	23	19.5	.09	16.0	12.8	.10	8.8	8.0	.13	5.1	4.5	.17
6	19.3	16.2	.12	13.3	10.7	.15	7.3	6.7	19	4.2	3.8	.25
7	16.6	13.9	.17	11.4	9.1	.20	6.3	5.7	.25	3.6	3.2	.34
8	14.5	12.2	.22	10.0	8.0	.27	5.5	5.0	.33			
9	12.9	10.8	.28	8.9	7.1	.34	4.9	4 4	.42			
10	11.6	9.7	.35	8.0	6.4	.41						
11	10.5	8.8	.42	7.3	5.8	.50						
12	9.7	8.1	.50									
13	8.9	7.3	.58									

Note:
D = Deflection in Inches.

PROPERTIES AND REACTION VALUES

S in.³	8.7	7.3	See Page 173	6.0	4.8	See Page 173	3.3	3.0	See Page 173	1.9	1.7	See Page 173
V kips	36	17.9		32	13.7		17.0	9.9		13.6	6.6	
R kips	*47*	*24*		*30*	*21*		*32*	*18.8*		*34*	*16.6*	
G kips	11.2	6.5		11.9	5 0		7.8	4.6		8.4	4.1	
N in.	2.5	2.5		2.0	2.0		1.5	1.5		1.1	1.1	

Values of R in italics exceed maximum web shear V.

MISCELLANEOUS LIGHT BEAMS (B)

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see pages 172-3.

Span in Feet	Nominal Depth and Width—Weight per Foot										
	†14 x 4	‡12 x 4			‡10 x 4			*8 x 4		*6 x 4	
	17.2	22	19	16.5	19	17	15	15	13	16	12
d/bt	12.8	7.2	8.7	11.2	6.5	7.7	9.3	6.5	7.9	3.8	5.4
L_u	3.8	7	5.5	4.5	7.5	6.5	5.5	7.5	6	13	9
2									48		36
3			76	72	66	64	60	52	44	42	32
4	70	84	71	58	63	54	46	39	33	34	24
5	56	68	57	47	50	43	37	32	26	27	19.3
6	46	56	48	39	42	36	31	26	22	22	16.1
7	40	48	41	33	36	31	26	23	18.8	19.2	13.8
8	35	42	36	29	31	27	23	19.7	16.5	16.8	12.1
9	31	38	32	26	28	24	20	17.5	14.6	15.0	10.7
10	28	34	29	23	25	22	18.4	15.7	13.2	13.5	9.7
11	25	31	26	21	23	19.6	16.7	14.3	12.0	12.2	8.8
12	23	28	24	19.4	21	18.0	15.3	13.1	11.0	11.2	8.0
13	21	26	22	17.9	19.3	16.6	14.2	12.1	10.1	10.4	7.4
14	20	24	20	16.7	17.9	15.4	13.1	11.2	9.4		
15	18.7	23	19.0	15.6	16.7	14.4	12.3	10.5	8.8		
16	17.5	21	17.8	14.6	15.7	13.5	11.5	9.8	8.2		
17	16.4	19.8	16.8	13.7	14.7	12.7	10.8	9.3	7.7		
18	15.5	18.7	15.9	13.0	13.9	12.0	10.2				
19	14.7	17.8	15.0	12.3	13.2	11.4	9.7				
20	14.0	16.9	14.3	11.7	12.5	10.8	9.2				
21	13.3	16.1	13.6	11.1	11.9	10.3	8.8				
22	12.7	15.3	13.0	10.6							
23	12.1	14.7	12.4	10.1							
24	11.6	14.1	11.9	9.7							
25	11.2	13.5	11.4	9.3							
26	10.7										
27	10.3										
28	10.0										
29	9.3										
30	8.7										

PROPERTIES AND REACTION VALUES

S in.^{3}	21.0	25.3	21.4	17.5	18.8	16.2	13.8	11.8	9.88	10.1	7.24
V kips	38	42	38	36	33	32	30	26	24	21	17.9
R kips	20	27	24	23	25	24	22	24	22	*26*	*22*
G kips	5.0	6.2	5.8	5.5	6.0	5.8	5.5	5.9	5.5	6.2	5.5
N in.	7.0	5.9	5.9	5.9	4.9	4.9	4.9	3.8	3.8	2.7	2.7

‡Rolled by Bethlehem Steel Co. United States Steel Corp. and Inland Steel Co.
†Rolled by Jones & Laughlin Steel Corp.
*Rolled by Bethlehem Steel Co. and United States Steel Corp.
Values of R in italics exceed maximum web shear V.

MISCELLANEOUS
LIGHT BEAMS AND JOISTS

(B)

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS LATERALLY SUPPORTED

For beams laterally unsupported, see pages 172-3.

Span in Feet	Nominal Depth and Width—Weight per Foot									
	‡12 x 4	‡10 x 4	*8 x 4	*6 x 4	†10 x 5¾		†8 x 6½		†8 x 5¼	
	14	11.5	10	8.5	25	21	28	24	20	17
d/bt	13.4	12.3	9.8	7.7	4.5	4.6	3.2	3.3	4.8	4.9
L_u	3.5	4	5	6.5	11	11	15	15	10	10
2				26					72	
3	62	46	35	23	90		82		67	
4	49	35	26	16.9	79	62	75		51	47
5	40	28	21	13.5	63	58	60	51	41	37
6	33	23	17.3	11.3	52	48	50	46	34	31
7	28	20	14.8	9.7	45	41	43	40	29	27
8	25	17.5	13.0	8.5	39	36	38	35	25	23
9	22	15.6	11.5	7.5	35	32	33	31	23	21
10	19.7	14.0	10.4	6.8	32	29	30	28	20	18.7
11	17.9	12.7	9.4	6.1	29	26	27	25	18.4	17.0
12	16.4	11.7	8.7	5.6	26	24	25	23	16.9	15.6
13	15.2	10.8	8.0	5.2	24	22	23	21	15.6	14.4
14	14.1	10.0	7.4		23	21	21	19.9	14.5	13.3
15	13.2	9.3	6.9		21	19.3	20	18.6	13.5	12.4
16	12.3	8.7	6.5		19.7	18.1	18.7	17.4	12.7	11.7
17	11.6	8.2	6.1		18.5	17.0	17.6	16.4	11.9	11.0
18	11.0	7.8			17.5	16.1				
19	10.4	7.4			16.6	15.2				
20	9.9	7.0			15.7	14.5				
21	9.4	6.7			15.0	13.8				
22	9.0									
23	8.6									
24	8.2									
25	7.9									

PROPERTIES AND REACTION VALUES

S in.^{3}	14.8	10.5	7.79	5.07	23.6	21.7	22.5	20.9	15.2	14.0
V kips	31	23	17.5	12.9	45	31	41	25	36	25
R kips	19.5	17.3	16.3	*16.1*	36	25	41	25	35	24
G kips	4.8	4.3	4.1	4.1	8.4	5.8	9.4	5.9	8.4	5.8
N in.	5.9	4.9	3.8	2.7	4.6	4.6	3.5	3.5	3.6	3.6

*Rolled by Bethlehem Steel Co. and United States Steel Corp.
†Rolled by The Phoenix Iron Co.
‡Rolled by United States Steel Corp., Bethlehem Steel Co., Inland Steel Co. and Jones & Laughlin Steel Corp.
Values of R in italics exceed maximum web shear V.

⊕ JUNIOR BEAMS AND JUNIOR CHANNELS

JR.

ALLOWABLE UNIFORM LOADS IN KIPS FOR BEAMS AND CHANNELS LATERALLY SUPPORTED

For beams and channels laterally unsupported, allowable loads must be reduced.

Span in Feet	Nominal Depth and Width—Weight per Foot						
	Beams				Channels		
	12 x 3	10 x $2\frac{5}{8}$	8 x $2\frac{1}{4}$	6 x $1\frac{7}{8}$	12 x $1\frac{1}{2}$	10 x $1\frac{1}{2}$	10 x $1\frac{1}{8}$
	11.8	9.0	6.5	4.4	10.6	8.4	6.5
d/bt	16	20	19	17			
L_u	3	2.5	2.5	3			
2	54	40	28		59		
3	53	35	21	10.7	41	29	19.5
4	40	26	15.7	8.0	31	20.6	14.7
5	32	21	12.5	6.4	25	17.3	11.7
6	27	17.3	10.4	5.3	20.6	14.4	9.8
7	23	14.9	9.0	4.6	17.7	12.4	8.4
8	20	13.0	7.8	4.0	15.5	10.8	7.3
9	17.8	11.6	7.0	3.6	13.8	9.6	6.5
10	16.0	10.4	6.3	3.2	12.4	8.7	5.9
11	14.5	9.5	5.7	2.9	11.3	7.9	
12	13.3	8.7	5.2	2.7	10.3	7.2	
13	12.3	8.0	4.8	2.5	9.5	6.7	
14	11.4	7.4	4.5		8.8		
15	10.7	6.9	4.2		8.3		
16	10.0	6.5	3.9		7.7		
17	9.4	6.1	3.7		7.3		
18	8.9	5.8					
19	8.4	5.5					
20	8.0	5.2					
21	7.6	5.0					
22	7.3						
23	7.0						
24	6.7						
25	6.4						

PROPERTIES AND REACTION VALUES

	12 x 3	10 x $2\frac{5}{8}$	8 x $2\frac{1}{4}$	6 x $1\frac{7}{8}$	12 x $1\frac{1}{2}$	10 x $1\frac{1}{2}$	10 x $1\frac{1}{8}$
S $in.^3$	12.0	7.8	4.7	2.4	9.3	6.5	4.4
V kips	27	20	14.0	8.9	29.6	22.1	19.5
R kips	16.8	14.7	12.6	*10.6*			
G kips	4.2	3.7	3.2	2.7			
N in.	6.0	5.0	4.0	2.9			

⊕ Rolled by Jones & Laughlin Steel Corp.
Values of R in italics exceed maximum web shear V.

18-15 BEAMS

AMERICAN STANDARD CHANNELS

ALLOWABLE UNIFORM LOADS IN KIPS FOR CHANNELS LATERALLY SUPPORTED

For channels laterally unsupported, allowable loads must be reduced.

Span in Feet	Nominal Depth and Width—Weight per Foot								
	18 x 4				Deflection Inches	15 x 3½			Deflection Inches
	58	51.9	45.8	42.7		50	40	33.9	
2						280			.01
3	328	280	234	210	.01	238	202	156	.01
4	248	230	212	203	.02	178	154	139	.02
5	199	184	170	163	.03	143	123	111	.03
6	166	154	142	136	.04	119	103	93	.05
7	142	132	121	116	.06	102	88	79	.07
8	124	115	106	102	.07	89	77	70	.09
9	110	102	94	90	.09	79	68	62	.11
10	99	92	85	81	.12	71	62	56	.14
11	90	84	77	74	.14	65	56	51	.17
12	83	77	71	68	.17	59	51	46	.20
13	76	71	65	63	.19	55	47	43	.23
14	71	66	61	58	.23	51	44	40	.27
15	66	61	57	54	.26	48	41	37	.31
16	62	58	53	51	.29	45	39	35	.35
17	58	54	50	48	.33	42	36	33	.40
18	55	51	47	45	.37	40	34	31	.45
19	52	49	45	43	.42	38	32	29	.50
20	50	46	43	41	.46	36	31	28	.55
21	47	44	40	39	.51	34	29	27	.61
22	45	42	39	37	.56	32	28	25	.67
23	43	40	37	35	.61	31	27	24	.73
24	41	38	35	34	.66	30	26	23	.79
25	40	37	34	33	.72	29	25	22	.86
26	38	35	33	31	.78	27	24	21	.93
27	37	34	32	30	.84	26	23	21	1.01
28	36	33	30	29	.90	26	22	19.9	1.08
29	34	32	29	28	.97	25	21	19.2	1.16
30	33	31	28	27	1.03	24	21	18.5	1.24
31	32	30	27	26	1.11	23	19.9	17.9	1.33
32	31	29	27	25	1.18	22	19.3	17.4	1.41
33	30	28	26	25	1.25	22	18.7	16.8	1.50
34	29	27	25	24	1.33	21	18.1	16.4	1.60
35	28	26	24	23	1.41	20	17.6	15.9	1.69
36	28	26	24	23	1.49	19.8	17.1	15.4	1.79
37	27	25	23	22	1.57	19.3	16.7	15.0	1.89
38	26	24	22	21	1.66	18.7	16.2	14.6	1.99
39	25	24	22	21	1.75				
40	25	23	21	20	1.84				
42	24	22	20	19.4	2.03				
44	23	21	19.3	18.5	2.23				

PROPERTIES AND REACTION VALUES

	58	51.9	45.8	42.7		50	40	33.9	
S in.³	74.5	69.1	63.7	61.0	See Page 173	53.6	46.2	41.7	See Page 173
V kips	164	140	117	105		140	101	78	
R kips	81	69	58	52		83	60	46	
G kips	16.8	14.4	12.0	10.8		17.2	12.5	9.6	
N in.	8.4	8.4	8.4	8.4		6.8	6.8	6.8	

BEAMS 12-10

AMERICAN STANDARD CHANNELS

ALLOWABLE UNIFORM LOADS IN KIPS FOR CHANNELS LATERALLY SUPPORTED

For channels laterally unsupported, allowable loads must be reduced.

Span in Feet	Nominal Depth and Width—Weight per Foot								
	12 x 3			Deflection Inches	10 x $2\frac{5}{8}$				Deflection Inches
	30	25	20.7		30	25	20	15.3	
2	160	120		.01			98	62	.01
3	120	106	88	.02	92	80	70	60	.02
4	90	80	71	.03	69	60	52	45	.03
5	72	64	57	.04	55	48	42	36	.05
6	60	53	48	.06	46	40	35	30	.07
7	51	46	41	.08	39	35	30	26	.10
8	45	40	36	.11	34	30	26	22	.13
9	40	35	32	.14	31	27	23	19.9	.17
10	36	32	29	.17	28	24	21	17.9	.21
11	33	29	26	.21	25	22	19.0	16.2	.25
12	30	27	24	.25	23	20	17.4	14.9	.30
13	28	25	22	.29	21	18.6	16.1	13.7	.35
14	26	23	20	.34	19.6	17.2	15.0	12.8	.41
15	24	21	19.0	.39	18.3	16.1	14.0	11.9	.47
16	22	19.9	17.8	.44	17.2	15.1	13.1	11.2	.53
17	21	18.7	16.8	.50	16.2	14.2	12.3	10.5	.60
18	19.9	17.7	15.9	.56	15.3	13.4	11.6	9.9	.67
19	18.9	16.8	15.0	.62	14.5	12.7	11.0	9.4	.75
20	17.9	15.9	14.3	.69	13.7	12.1	10.5	8.9	.83
21	17.1	15.2	13.6	.76	13.1	11.5	10.0	8.5	.91
22	16.3	14.5	13.0	.83	12.5	11.0	9.5	8.1	1.00
23	15.6	13.9	12.4	.91	11.9	10.5	9.1	7.8	1.10
24	14.9	13.3	11.9	.99	11.4	10.1	8.7	7.4	1.19
25	14.3	12.7	11.4	1.08	11.0	9.7	8.4	7.1	1.29
26	13.8	12.3	11.0	1.17					
27	13.3	11.8	10.6	1.26					
28	12.8	11.4	10.2	1.35					
29	12.4	11.0	9.8	1.45					
30	12.0	10.6	9.5	1.55					

PROPERTIES AND REACTION VALUES

S in.^{3}	26.9	23.9	21.4	See Page 173	20.6	18.1	15.7	13.4	See Page 173
V kips	80	60	44		88	68	49	31	
R kips	56	42	31		72	56	40	26	
G kips	12.2	9.3	6.7		16.2	12.6	9.1	5.8	
N in.	5.4	5.4	5.4		4.5	4.5	4.5	4.5	

9-8-7 BEAMS

AMERICAN STANDARD CHANNELS

ALLOWABLE UNIFORM LOADS IN KIPS FOR CHANNELS LATERALLY SUPPORTED

For channels laterally unsupported, allowable loads must be reduced.

Nominal Depth and Width—Weight per Foot

Span in Feet	9 x 2½			Deflection Inches	8 x 2¼			Deflection Inches	7 x 2⅛			Deflection Inches
	20	15	13.4		18.75	13.75	11.5		14.75	12.25	9.8	
2		66	54	.01			46	.01			38	.01
3	60	50	47	.02	48	40	36	.02	34	31	27	.03
4	45	38	35	.04	36	30	27	.04	26	23	20	.05
5	36	30	28	.06	29	24	22	.07	21	18.4	16	.07
6	30	25	23	.08	24	20	18.0	.09	17.1	15.3	13.3	.11
7	26	22	20	.11	21	17.1	15.4	.13	14.7	13.1	11.4	.15
8	23	18.8	17.5	.15	18.2	15.0	13.5	.17	12.8	11.5	10.0	.19
9	20	16.7	15.6	.19	16.1	13.3	12.0	.21	11.4	10.2	8.9	.24
10	18.0	15.1	14.0	.23	14.5	12.0	10.8	.26	10.3	9.2	8.0	.30
11	16.4	13.7	12.7	.28	13.2	10.9	9.8	.31	9.3	8.4	7.3	.36
12	15.0	12.6	11.7	.33	12.1	10.0	9.0	.37	8.6	7.7	6.7	.43
13	13.8	11.6	10.8	.39	11.2	9.2	8.3	.44	7.9	7.1	6.2	.50
14	12.9	10.8	10.0	.45	10.4	8.6	7.7	.51	7.3	6.6	5.7	.58
15	12.0	10.0	9.3	.52	9.7	8.0	7.2	.58	6.8	6.1	5.3	.67
16	11.2	9.4	8.7	.59	9.1	7.5	6.7	.66	6.4	5.7	5.0	.76
17	10.6	8.9	8.2	.66	8.5	7.1	6.4	.75	6.0	5.4	4.7	.85
18	10.0	8.4	7.8	.75	8.1	6.7	6.0	.84	5.7	5.1	4.4	.96
19	9.5	7.9	7.4	.83	7.6	6.3	5.7	.93				
20	9.0	7.5	7.0	.92	7.3	6.0	5.4	1.04				
21	8.6	7.2	6.7	1.01								
22	8.2	6.8	6.4	1.11								
23	7.8	6.6	6.1	1.22								

PROPERTIES AND REACTION VALUES

S in.³	13.5	11.3	10.5	See Page 173	10.9	9.0	8.1	See Page 173	7.7	6.9	6.0	See Page 173
V kips	52	33	27		51	32	23		38	29	19.1	
R kips	47	30	24		50	31	23		*43*	*33*	*22*	
G kips	10.8	6.8	5.5		11.7	7.3	5.3		10.1	7.5	5.0	
N in.	4.0	4.0	4.0		3.5	3.5	3.5		3.0	3.0	3.0	

Values of R in italics exceed maximum web shear V.

BEAMS

6-5-4-3

AMERICAN STANDARD CHANNELS

ALLOWABLE UNIFORM LOADS IN KIPS FOR CHANNELS LATERALLY SUPPORTED

For channels laterally unsupported, allowable loads must be reduced.

Span in Feet	Nominal Depth and Width—Weight per Foot													
	6 x 2			Deflection Inches	5 x 1¾		Deflection Inches	4 x 1⅝		Deflection Inches	3 x 1½			Deflection Inches
	13.0	10.5	8.2		9.0	6.7		7.25	5.4		6.0	5.0	4.1	
3	26	22	19.1	.03	15.6	13.3	.04	10.2	8.4	.05	6.2	5.3	4.9	.06
4	19.3	16.7	14.3	.06	11.7	10.0	.07	7.7	6.3	.08	4.7	4.0	3.7	.11
5	15.5	13.3	11.5	.09	9.3	8.0	.10	6.1	5.1	.13	3.7	3.2	2.9	.17
6	12.9	11.1	9.6	.12	7.8	6.7	.15	5.1	4.2	.19	3.1	2.7	2.4	.25
7	11.0	9.5	8.2	.17	6.7	5.7	.20	4.4	3.6	.25	2.7	2.3	2.1	.34
8	9.7	8.3	7.2	.22	5.8	5.0	.27	3.8	3.2	.33	2.3	2.0	1.8	.44
9	8.6	7.4	6.4	.28	5.2	4.4	.34	3.4	2.8	.42				
10	7.7	6.7	5.7	.35	4.7	4.0	.41	3.1	2.5	.52				
11	7.0	6.1	5.2	.42	4.2	3.6	.50							
12	6.4	5.6	4.8	.50	3.9	3.3	.60							
13	5.9	5.1	4.4	.58	3.6	3.1	.70							
14	5.5	4.8	4.1	.68										
15	5.2	4.4	3.8	.78										

PROPERTIES AND REACTION VALUES

S in.³	5.8	5.0	4.3	See Page 173	3.5	3.0	See Page 173	2.3	1.9	See Page 173	1.4	1.2	1.1	See Page 173
V kips	34	25	15.6		21	12.4		16.6	9.4		13.9	10.1	6.6	
R kips	*45*	*32*	*20*		*33*	*19.1*		*32*	*17.8*		*35*	*26*	*16.9*	
G kips	10.5	7.5	4.8		7.8	4.6		7.7	4.3		8.5	6.2	4.1	
N in.	2.5	2.5	2.5		2.0	2.0		1.5	1.5		1.0	1.0	1.0	

Values of R in italics exceed maximum web shear V.

BEAMS

REGULAR SERIES ANGLES

ALLOWABLE UNIFORM LOADS IN KIPS FOR ANGLES LATERALLY SUPPORTED NEUTRAL AXIS PARALLEL TO HORIZONTAL LEG

For angles laterally unsupported, allowable loads must be reduced.
For angles subject to torsion, make special investigation.

Horizontal Leg	Angle Size	Wt. per Ft.	Span in Feet										
			4	5	6	7	8	9	10	12	14	16	18
8″	8 x 8 x 1	51.0	52	42	35	30	26	23	21	17.6	15.0	13.2	11.7
	7/8	45.0	46	37	31	26	23	20	18.7	15.6	13.3	11.7	10.4
	3/4	38.9	40	32	27	23	20	18.1	16.3	13.6	11.6	10.2	9.0
	5/8	32.7	34	27	22	19.6	17.2	15.3	13.7	11.4	9.8	8.6	7.6
	1/2	26.4	28	22	18.7	16.0	14.0	12.4	11.2	9.3	8.0	7.0	6.2
	8 x 6 x 9/16	25.7	17.6	14.1	11.8	10.1	8.8	7.8	7.1	5.9	5.0		
	7/16	20.2	14.0	11.2	9.3	8.0	7.0	6.2	5.6	4.7	4.0		
	8 x 4 x 7/16	17.2	6.3	5.1	4.2	3.6	3.2	2.8	2.5				
7″	7 x 4 x 3/4	26.2	10.0	8.0	6.7	5.7	5.0	4.4					
	5/8	22.1	8.7	6.9	5.8	5.0	4.3	3.9					
	1/2	17.9	7.0	5.6	4.7	4.0	3.5	3.1					
	7/16	15.8	6.2	5.0	4.2	3.5	3.1	2.8					
6″	8 x 6 x 3/4	33.8	39	31	26	22	19.5	17.3	15.6	13.0	11.1	9.7	
	5/8	28.5	33	26	22	18.9	16.5	14.7	13.2	11.0	9.4	8.2	
	1/2	23.0	26	21	17.8	15.2	13.3	11.8	10.7	8.9	7.6	6.7	
	7/16	20.2	23	18.9	15.8	13.5	11.8	10.5	9.5	7.9	6.8	5.9	
	6 x 6 x 7/16	17.2	13.7	10.9	9.1	7.8	6.8	6.1	5.5	4.6	3.9		
	3/8	14.9	11.7	9.3	7.8	6.7	5.8	5.2	4.7	3.9	3.3		
	6 x 4 x 7/16	14.3	6.3	5.1	4.2	3.6	3.2	2.8					
5″	5 x 5 x 5/8	20.0	13.0	10.4	8.7	7.4	6.5	5.8	5.2				
	1/2	16.2	10.7	8.5	7.1	6.1	5.3	4.7	4.3				
	3/8	12.3	8.0	6.4	5.3	4.6	4.0	3.6	3.2				
	5 x 3½ x 3/8	10.4	4.0	3.2	2.7	2.3	2.0						
	5/16	8.7	3.3	2.7	2.2	1.9	1.7						
4″	9 x 4 x 1	40.8	59	47	39	33	29	26	23	19.6	16.8	14.7	
	7/8	36.1	52	42	35	30	26	23	21	17.4	14.9	13.1	
	3/4	31.2	45	36	30	26	23	20	18.1	15.1	13.0	11.3	
	5/8	26.3	38	31	26	22	19.1	17.0	15.3	12.8	10.9	9.6	
	9/16	23.8	35	28	23	19.8	17.3	15.4	13.8	11.5	9.9	8.7	
	1/2	21.3	31	25	21	17.7	15.5	13.8	12.4	10.3	9.0	7.8	
4″	8 x 4 x 5/8	24.2	30	24	20	17.5	15.3	13.6	12.3	10.2	8.8	7.7	
	1/2	19.6	25	20	16.7	14.3	12.5	11.1	10.0	8.3	7.1	6.2	
	7/16	17.2	22	17.6	14.7	12.6	11.0	9.8	8.8	7.3	6.3	5.5	

BEAMS

REGULAR SERIES ANGLES

ALLOWABLE UNIFORM LOADS IN KIPS
FOR ANGLES LATERALLY SUPPORTED
NEUTRAL AXIS PARALLEL TO HORIZONTAL LEG

For angles laterally unsupported, allowable loads must be reduced.
For angles subject to torsion, make special investigation.

Horizontal Leg	Angle Size	Wt. per Ft.	Span in Feet 2	3	4	5	6	7	8	9	10	12	14
4″	7 x 4 x $\frac{7}{16}$	15.8	......	......	17.0	13.6	11.3	9.7	8.5	7.6	6.8	5.7	4.9
	$\frac{3}{8}$	13.6	......	......	14.7	11.7	9.8	8.4	7.3	6.5	5.9	4.9	4.2
	6 x 4 x $\frac{3}{8}$	12.3	......	......	11.0	8.8	7.3	6.3	5.5	4.9	4.4	3.7	
	4 x 4 x $\frac{3}{8}$	9.8	......	......	5.0	4.0	3.3	2.9	2.5	2.2			
	$\frac{5}{16}$	8.2	......	......	4.3	3.5	2.9	2.5	2.2	1.9			
	4 x $3\frac{1}{2}$ x $\frac{5}{16}$	7.7	......	......	3.3	2.7	2.2	1.9	1.7				
	4 x 3 x $\frac{5}{16}$	7.2	......	......	2.4	1.9	1.6	1.4					
	$\frac{1}{4}$	5.8	......	......	2.0	1.6	1.3	1.1					
$3\frac{1}{2}$″	5 x $3\frac{1}{2}$ x $\frac{1}{2}$	13.6	20.0	13.3	10.0	8.0	6.7	5.7	5.0	4.4	4.0		
	$\frac{3}{8}$	10.4	15.3	10.2	7.7	6.1	5.1	4.4	3.8	3.4	3.1		
	$\frac{5}{16}$	8.7	12.7	8.4	6.3	5.1	4.2	3.6	3.2	2.8	2.5		
	4 x $3\frac{1}{2}$ x $\frac{5}{16}$	7.7	8.7	5.8	4.3	3.5	2.9	2.5	2.2	1.9			
	$3\frac{1}{2}$ x $3\frac{1}{2}$ x $\frac{5}{16}$	7.2	6.5	4.4	3.3	2.6	2.2	1.9	1.6				
	$\frac{1}{4}$	5.8	5.3	3.5	2.6	2.1	1.8	1.5	1.3				
	$3\frac{1}{2}$ x 3 x $\frac{1}{4}$	5.4	3.9	2.6	1.9	1.5	1.3	1.1					
3″	4 x 3 x $\frac{1}{2}$	11.1	12.7	8.4	6.3	5.1	4.2	3.6	3.2				
	$\frac{3}{8}$	8.5	10.0	6.7	5.0	4.0	3.3	2.9	2.5				
	$\frac{5}{16}$	7.2	8.0	5.3	4.0	3.2	2.7	2.3	2.0				
	$\frac{1}{4}$	5.8	6.7	4.4	3.3	2.7	2.2	1.9	1.7				
	$3\frac{1}{2}$ x 3 x $\frac{1}{4}$	5.4	5.2	3.5	2.6	2.1	1.7	1.5					
	3 x 3 x $\frac{1}{4}$	4.9	3.9	2.6	1.9	1.5	1.3						
	3 x $2\frac{1}{2}$ x $\frac{1}{4}$	4.5	2.7	1.8	1.3	1.1							
$2\frac{1}{2}$″	3 x $2\frac{1}{2}$ x $\frac{3}{8}$	6.6	5.4	3.6	2.7	2.2	1.8						
	$\frac{5}{16}$	5.6	4.6	3.1	2.3	1.8	1.5						
	$\frac{1}{4}$	4.5	3.7	2.5	1.9	1.5	1.2						
	$2\frac{1}{2}$ x $2\frac{1}{2}$ x $\frac{1}{4}$	4.1	2.6	1.7	1.3	1.0							
	$2\frac{1}{2}$ x 2 x $\frac{1}{4}$	3.62	1.7	1.1	0.8								

ALLOWABLE LOADS ON BEAMS WITHOUT LATERAL SUPPORT

Up to a certain span (called in the tables on pp. 175 to 195 "L_u"), a beam will carry the same load without, as with, lateral support. On greater spans the danger of lateral buckling enters, and the beam must be protected by reducing the allowable load below what would be permitted (as tabulated on pages 175 to 201) in the presence of full lateral support.

The span "L_u" is defined by the formula "$\frac{ld}{bt}$ not to exceed 600." (See page 172).

This span length is tabulated for each I beam, and the designer of a laterally unsupported beam will know automatically that if its span does not exceed "L_u" the tabulated load may be applied.

If the span does exceed "L_u" the unit stress is to be reduced below 20,000 p.s.i., in accordance with the formula

$$f = \frac{12,000,000}{\frac{ld}{bt}}$$

"$\frac{d}{bt}$" is entered at the top of each I beam table, and will be multiplied by the span **in inches** to solve this formula for "f". The tabulated beam capacity will then be reduced in the ratio of f/20,000.

In the most general case, however, the designer will be confronted with a given (laterally unsupported) span and a calculated moment, from which to select a beam. This is not easy to do by direct consideration of section modulus, as the depth and the flange proportions (determinants of torsional strength) have an influence comparable to that of bending strength. The selection of the proper beam can be immediately made by referring to the following four charts.

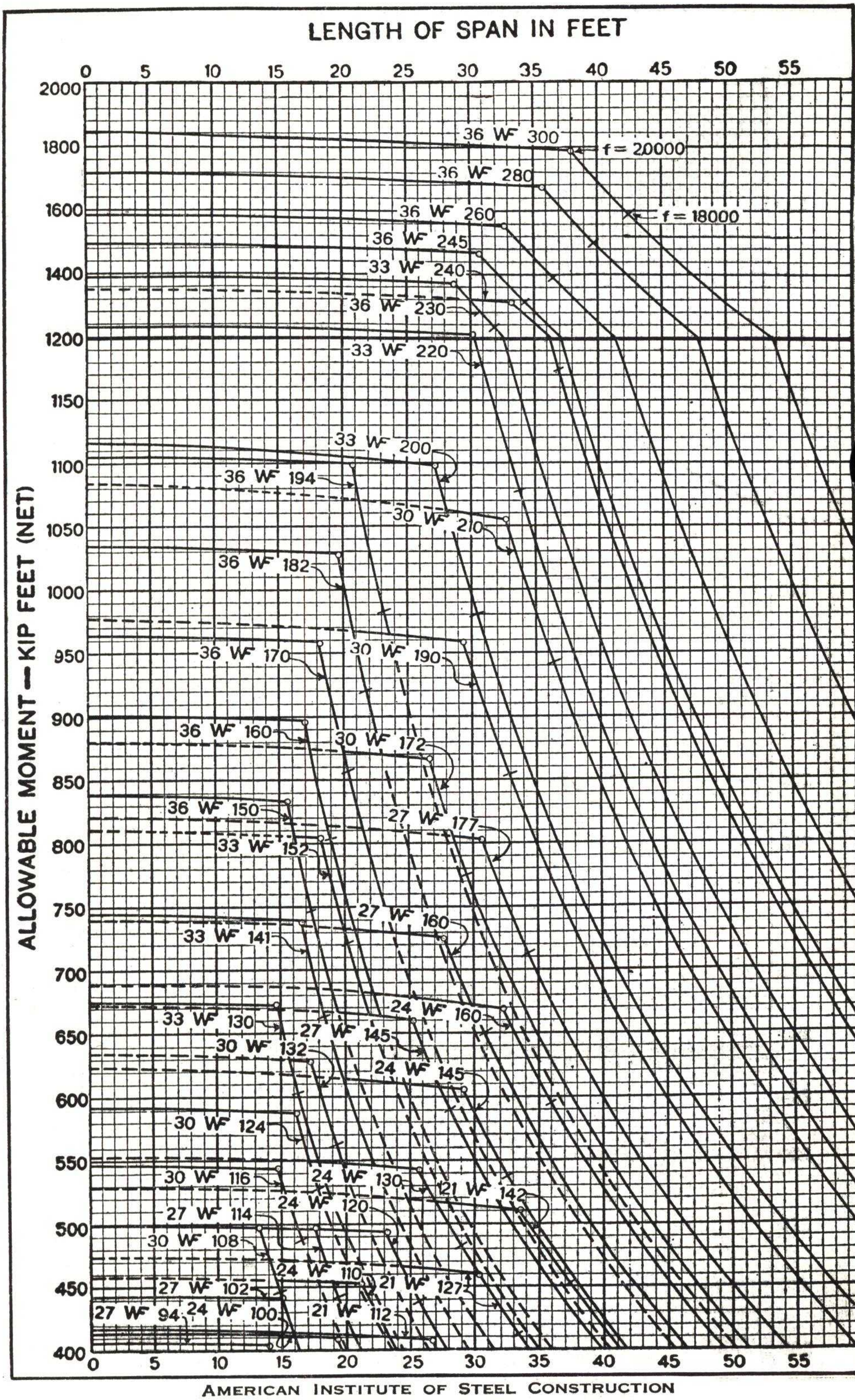
The moment capacities shown on the charts take into account the moment due to the weight of the beam, thereby avoiding any need for guessing a weight of beam in the course of the moment calculations.

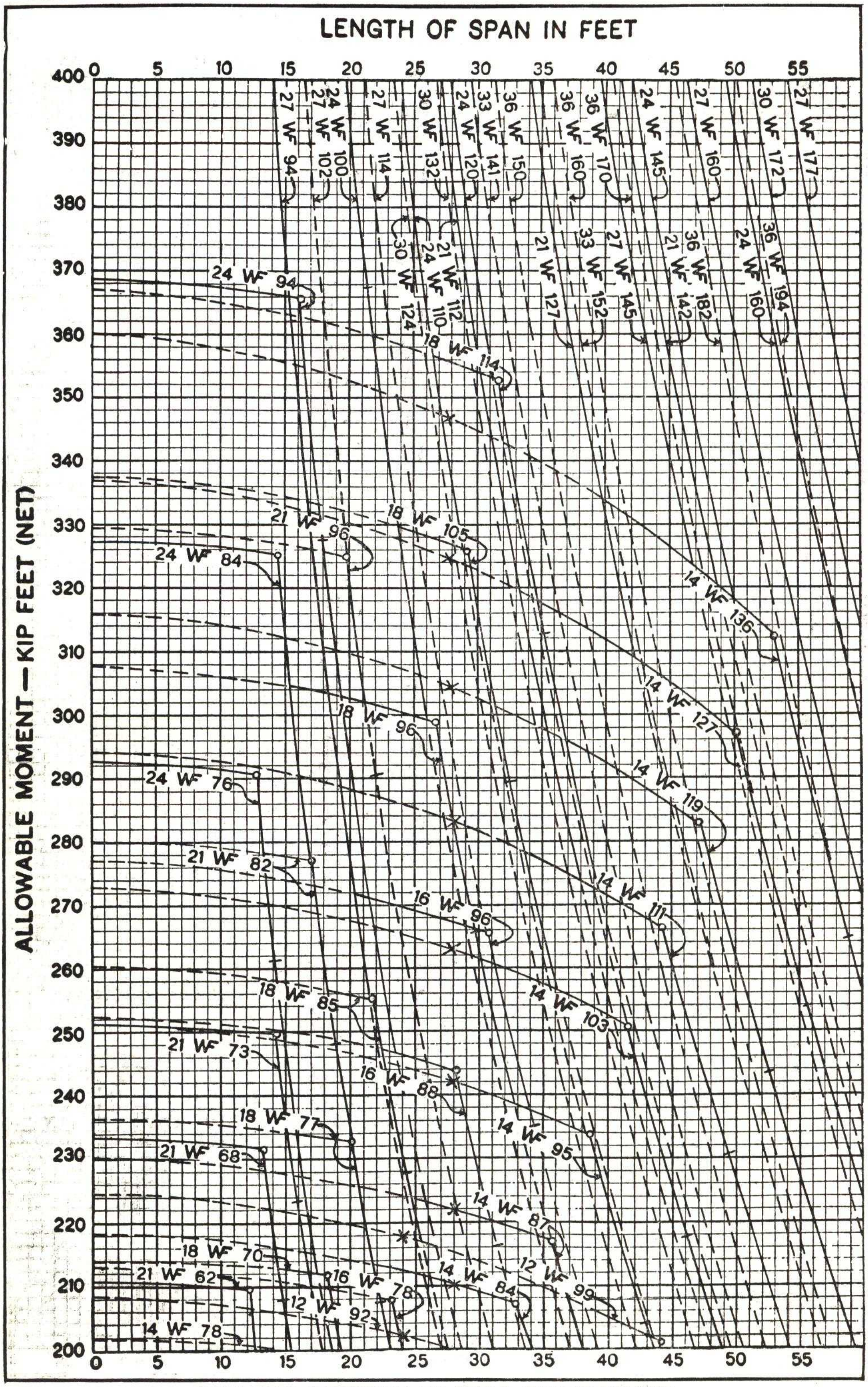
For instance, suppose that concentrated loads on a beam with laterally unsupported span of 40 ft. produce a moment of 260 kip ft. without including the weight of the beam. Entering the chart on page 204 with the figure 40 on the bottom scale, proceed upwards to meet the horizontal line coming in from 260 on the left-hand scale. Any beam listed above or to the right is safe. These include 24 WF @ 120
18 WF @ 114
33 WF @ 141, etc. It is seen that the 18 WF, although its section modulus is only 220 compared to 299 for the 24 WF, is equally able to carry the moment because of having a more compact and torsionally resistant section.

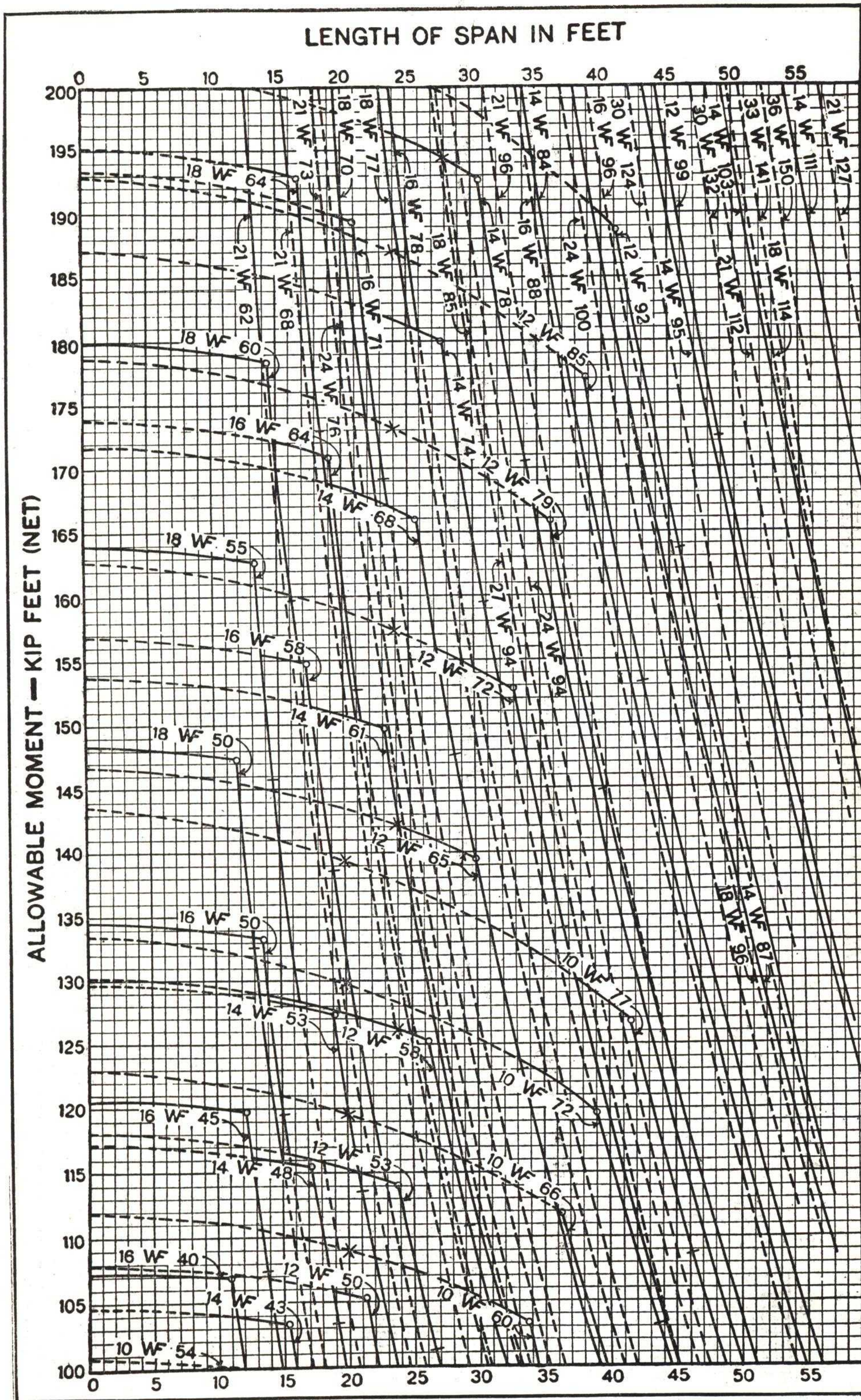
Because several of its dimensions are thus involved, a given beam is the lightest available for a certain combination of span and moment, over only a limited range of length. This is indicated on the charts by using a full line for this range and a broken line for the range or ranges in which some lighter beam is available. In the example above cited, it will be seen that the 18 WF @ 114 is shown by a full line in the region where the 40 ft. line and the 260 kip ft. line intersect.

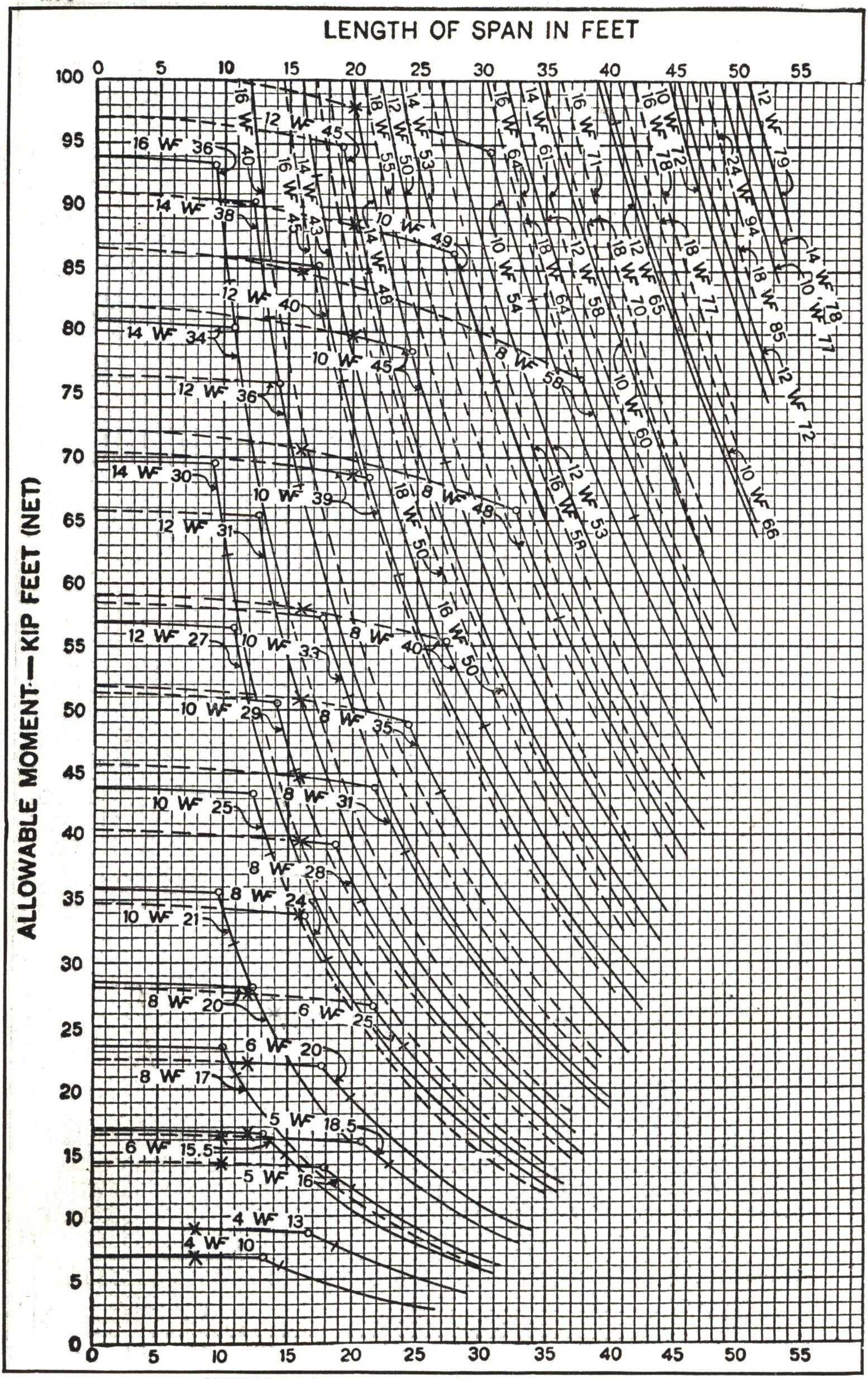
The charts include several beams of relatively square cross-section which under the capacity loads indicated will deflect vertically more than may be admissible. The symbol $\times$ is shown on the upper or flat curve for each such beam, at the span length which equals 24 times the depth (A.I.S.C. Spec. Sect. 17(a)); at which point the deflection under full uniform load equals $l/290$ or d/12.1. If the span length ordinate for a given case intersects the curve for a beam so marked, to the right of the symbol $\times$, the deflection for uniform load is greater than $l/290$, and requires consideration by the designer. In any other case, the deflection of the unsupported beam as selected from the charts is less than $l/290$. The curves have arbitrarily been stopped at a point where the total capacity equals four times the weight of the beam itself.

The charts are not extended to include channels and angles, for which safe loads on fully supported spans have been tabulated on pages 195 to 201. It is so difficult to load an unstayed channel or angle on the one vertical axis which eliminates torsion, and the actual torsional moment involved in any unsupported span is so uncertain, and so relatively great, that it is deemed impracticable to offer any short cut solution for such designs.


LENGTH OF SPAN IN FEET
ALLOWABLE MOMENT — KIP FEET (NET)
f = 20000
f = 18000
36 WF 300
36 WF 280
36 WF 260
36 WF 245
33 WF 240
36 WF 230
33 WF 220
33 WF 200
36 WF 194
30 WF 210
36 WF 182
36 WF 170
30 WF 190
36 WF 160
30 WF 172
36 WF 150
27 WF 177
33 WF 152
27 WF 160
33 WF 141
24 WF 160
33 WF 130
27 WF 145
30 WF 132
24 WF 145
30 WF 124
30 WF 116
24 WF 130
21 WF 142
24 WF 120
27 WF 114
30 WF 108
24 WF 110
27 WF 102
21 WF 127
27 WF 94
24 WF 100
21 WF 112


LENGTH OF SPAN IN FEET
ALLOWABLE MOMENT—KIP FEET (NET)
0 5 10 15 20 25 30 35 40 45 50 55
400 390 380 370 360 350 340 330 320 310 300 290 280 270 260 250 240 230 220 210 200
27 WF 94
27 WF 102
24 WF 100
27 WF 114
30 WF 132
24 WF 120
33 WF 141
36 WF 150
36 WF 160
36 WF 170
24 WF 145
27 WF 160
30 WF 172
27 WF 177
30 WF 124
24 WF 110
21 WF 112
21 WF 127
33 WF 152
27 WF 145
21 WF 142
36 WF 182
24 WF 160
36 WF 194
24 WF 94
18 WF 114
21 WF 96
18 WF 105
24 WF 84
14 WF 136
14 WF 127
18 WF 96
24 WF 76
14 WF 119
21 WF 82
16 WF 96
14 WF 111
18 WF 85
14 WF 103
21 WF 73
16 WF 88
18 WF 77
14 WF 95
21 WF 68
14 WF 87
18 WF 70
12 WF 99
21 WF 62
16 WF 78
14 WF 84
12 WF 92
14 WF 78


LENGTH OF SPAN IN FEET
ALLOWABLE MOMENT — KIP FEET (NET)
0
5
10
15
20
25
30
35
40
45
50
55
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
180
185
190
195
200
18 WF 64
21 WF 73
18 WF 70
18 WF 77
21 WF 96
14 WF 84
16 WF 96
30 WF 124
12 WF 99
30 WF 132
14 WF 103
33 WF 141
36 WF 150
14 WF 111
21 WF 127
21 WF 62
21 WF 68
16 WF 78
16 WF 71
18 WF 85
14 WF 78
16 WF 88
24 WF 100
12 WF 92
14 WF 95
21 WF 112
18 WF 114
18 WF 60
24 WF 76
14 WF 74
12 WF 85
16 WF 64
14 WF 68
12 WF 79
18 WF 55
27 WF 94
24 WF 94
16 WF 58
12 WF 72
14 WF 61
18 WF 50
12 WF 65
16 WF 50
10 WF 77
18 WF 96
14 WF 87
14 WF 53
12 WF 58
10 WF 72
16 WF 45
12 WF 53
14 WF 48
10 WF 66
16 WF 40
12 WF 50
14 WF 43
10 WF 60
10 WF 54


LENGTH OF SPAN IN FEET
ALLOWABLE MOMENT—KIP FEET (NET)

ALLOWABLE LOADS ON COLUMNS

The loads given in the following column tables are based on allowable unit stresses as follows (A.I.S.C. Spec. Section 15(a)(2)):

Columns with values of l/r not greater than 120, main or secondary members;

$$f = 17{,}000 - 0.485 \frac{l^2}{r^2} \text{ in p.s.i.}$$

Columns with values of l/r greater than 120;

a. Bracing and secondary members, $f = \dfrac{18{,}000}{1 + \dfrac{l^2}{18{,}000\, r^2}}$

b. Main members, $f = \dfrac{18{,}000}{1 + \dfrac{l^2}{18{,}000\, r^2}} \times \left(1.6 - \dfrac{\frac{l}{r}}{200} \right)$

For convenience in using these formulas a table of allowable unit stresses derived therefrom is given on page 209.

In the column tables which follow, allowable loads given below the horizontal heavy lines are for main members with l/r greater than 120. Allowable loads for bracing and secondary members of the same l/r may be derived therefrom, by the slide-rule process illustrated in Example 1 on page 210.

ECCENTRIC LOADING. The allowable loads given in the column tables are for columns axially or symmetrically loaded. For columns subjected both to direct loads and to bending produced by eccentric loads, the A.I.S.C. Specification in Section 12 (a) requires that the quantity

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \text{ shall not exceed unity.}$$

The use of Bending Factors (B_x and B_y) tabulated at the bottom of the load tables provides a convenient method of converting bending moments into equivalent direct loads in order to select a trial section from the load tables. B_x and B_y are respectively equal to the area divided by the appropriate section modulus.

EXAMPLE. A 14 WF column with an unbraced length of 12 ft. carries a concentric load of 300 kips and an eccentric load of 50 kips applied 18 inches from the major axis.* Design the column.

Assume the average bending factor of the group, say, $B_x = 0.185$, then

Bending Moment $= M = 50 \times 18 = 900$ inch kips.

Equivalent Direct Load $= MB_x = 900 \times 0.185 = 167$ kips.

Approximate column load $= 300 + 50 + 167 = 517$ kips.

A trial column section (111 pounds) is first selected from the tables as having a carrying capacity of 517 kips or more on an unbraced length of 12 feet. Since this selection is only tentative, it will be necessary to investigate the selected column as to its compliance with Section 12 (a).

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*The major and minor axes are frequently referred to in technical literature as the strong and weak axes.

Section	Allowable Column Load, Kips	Allowable Stress Axial F_a	Allowable Stress Bending F_b	Actual Stress Axial $f_a = \frac{P}{A}$	Actual Stress Bending $f_b = \frac{M}{S}$	$\frac{f_a}{F_a} + \frac{f_b}{F_b}$
		Kips per Square Inch				
14 WF 111	531	16.28	20.00	10.72	5.10	0.913
14 WF 95	455	16.27	20.00	12.53	5.98	1.069
14 WF 103	493	16.27	20.00	11.57	5.50	0.986(Use)

As shown in the above table, the 14 WF 111 column section first selected was found more than adequate. A 14 WF 95 section was next tried and found to be inadequate. A 14 WF 103 section was then investigated and found allowable. The lighter of the two adequate sections is used.

In designing columns subjected to bending about the minor axis only, F_b may be taken at 20.0 ksi. In designing columns subjected to bending about the major axis only, F_b must be limited in accordance with ld/bt, to the value permitted for unsupported beams under the provisions of Section 15(a) (3).

In designing columns subjected to bending about both axes, the expression

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \text{ becomes } \frac{f_a}{F_a} + \left(\frac{f_b}{F_b}\right)_{xx} + \left(\frac{f_b}{20.0}\right)_{yy},$$

in which F_b for the xx term is determined in accordance with ld/bt.

RATIO r_x/r_y. Allowable loads for columns are given in the tables for various lengths unbraced along the minor axis. It may be necessary, however, to investigate the capacity of columns with reference to both major and minor axes. The Ratio r_x/r_y included in these tables provides a rapid and convenient method of investigating the strength of the column with respect to the major axis.

Selection of a column from the tables is necessarily based on the greatest unbraced length l with reference to the radius of gyration r_y about the minor axis. To obtain the maximum unbraced length with reference to the radius of gyration r_x about the major axis it is only necessary to multiply the length l by the Ratio r_x/r_y. If the actual unbraced length with reference to the major axis is equal to or less than the length thus obtained, the selected section is adequate. If, however, the actual unbraced length with reference to the major axis is greater than the length thus obtained, the section is inadequate and must be redesigned.

EXAMPLE. A 12 WF column is required to carry a concentric load of 590 kips. The greatest unbraced length along the minor axis is 16 feet. The column is unbraced along the major axis for 31 feet.

Entering the column tables we find, on page 218 that at 16 feet a 12 WF 133 will carry an allowable load of 595 kips. This section will carry 590 kips at about 16.5 feet. The Ratio r_x/r_y is 1.77. The maximum length at which the column may be unbraced along the major axis is 16.5 x 1.77 = 29.2 feet. The section is therefore inadequate.

The next heavier column is the 12 WF 161 which will carry 590 kips at about 25.8 feet. The Ratio r_x/r_y is 1.78. The maximum length at which the column may be unbraced along the major axis is 25.8 x 1.78 = 46.0 feet. The section is adequate.

ALLOWABLE STRESSES PER SQUARE INCH

FOR

COMPRESSION MEMBERS

Main and Secondary Members, l/r not over 120, $f = 17000 - 0.485 \left(\frac{l}{r}\right)^2$						Secondary Members, l/r 121 to 200, $f = \frac{18000}{1 + \frac{l^2}{18000r^2}}$				Main Members, l/r 121 to 200, $\text{Do} \times \left(1.6 - \frac{l/r}{200}\right)$			
$\frac{l}{r}$	Unit Stress ksi.	$\frac{l}{r}$	Unit Stress ksi.	$\frac{l}{r}$	Unit Stress ksi.	$\frac{l}{r}$	Unit Stress ksi.	$\frac{l}{r}$	Unit Stress ksi.	$\frac{l}{r}$	Unit Stress ksi.	$\frac{l}{r}$	Unit Stress ksi.
1	17.00	41	16.19	81	13.82	121	9.93	161	7.38	121	9.88	161	5.87
2	17.00	42	16.14	82	13.74	122	9.85	162	7.32	122	9.75	162	5.78
3	17.00	43	16.10	83	13.66	123	9.78	163	7.27	123	9.63	163	5.71
4	16.99	44	16.06	84	13.58	124	9.71	164	7.22	124	9.52	164	5.63
5	16.99	45	16.02	85	13.50	125	9.64	165	7.16	125	9.40	165	5.55
6	16.98	46	15.97	86	13.41	126	9.56	166	7.11	126	9.27	166	5.47
7	16.98	47	15.93	87	13.33	127	9.49	167	7.06	127	9.16	167	5.40
8	16.97	48	15.88	88	13.24	128	9.42	168	7.01	128	9.04	168	5.33
9	16.96	49	15.84	89	13.16	129	9.35	169	6.96	129	8.93	169	5.25
10	16.95	50	15.79	90	13.07	130	9.28	170	6.91	130	8.82	170	5.18
11	16.94	51	15.74	91	12.98	131	9.22	171	6.86	131	8.71	171	5.11
12	16.93	52	15.69	92	12.90	132	9.15	172	6.81	132	8.60	172	5.04
13	16.92	53	15.64	93	12.81	133	9.08	173	6.76	133	8.49	173	4.97
14	16.91	54	15.59	94	12.72	134	9.01	174	6.71	134	8.38	174	4.90
15	16.89	55	15.53	95	12.62	135	8.94	175	6.66	135	8.27	175	4.83
16	16.88	56	15.48	96	12.53	136	8.88	176	6.62	136	8.17	176	4.77
17	16.86	57	15.42	97	12.44	137	8.81	177	6.57	137	8.06	177	4.70
18	16.84	58	15.37	98	12.34	138	8.75	178	6.52	138	7.96	178	4.63
19	16.83	59	15.31	99	12.25	139	8.68	179	6.47	139	7.86	179	4.56
20	16.81	60	15.25	100	12.15	140	8.62	180	6.43	140	7.76	180	4.50
21	16.79	61	15.20	101	12.05	141	8.55	181	6.38	141	7.65	181	4.43
22	16.77	62	15.14	102	11.95	142	8.49	182	6.34	142	7.56	182	4.37
23	16.74	63	15.08	103	11.86	143	8.43	183	6.29	143	7.46	183	4.31
24	16.72	64	15.01	104	11.75	144	8.36	184	6.25	144	7.36	184	4.25
25	16.70	65	14.95	105	11.65	145	8.30	185	6.20	145	7.26	185	4.19
26	16.67	66	14.89	106	11.55	146	8.24	186	6.16	146	7.17	186	4.13
27	16.65	67	14.82	107	11.45	147	8.18	187	6.12	147	7.08	187	4.07
28	16.62	68	14.76	108	11.34	148	8.12	188	6.07	148	6.98	188	4.01
29	16.59	69	14.69	109	11.24	149	8.06	189	6.03	149	6.89	189	3.95
30	16.56	70	14.62	110	11.13	150	8.00	190	5.99	150	6.80	190	3.89
31	16.53	71	14.56	111	11.02	151	7.94	191	5.95	151	6.71	191	3.84
32	16.50	72	14.49	112	10.92	152	7.88	192	5.91	152	6.62	192	3.78
33	16.47	73	14.42	113	10.81	153	7.82	193	5.86	153	6.53	193	3.72
34	16.44	74	14.34	114	10.70	154	7.77	194	5.82	154	6.45	194	3.67
35	16.41	75	14.27	115	10.59	155	7.71	195	5.78	155	6.36	195	3.61
36	16.37	76	14.20	116	10.47	156	7.65	196	5.74	156	6.27	196	3.56
37	16.34	77	14.12	117	10.36	157	7.60	197	5.70	157	6.19	197	3.51
38	16.30	78	14.05	118	10.25	158	7.54	198	5.66	158	6.11	198	3.45
39	16.26	79	13.97	119	10.13	159	7.49	199	5.62	159	6.03	199	3.40
40	16.22	80	13.90	120	10.02	160	7.43	200	5.59	160	5.94	200	3.35

COMPRESSION MEMBERS WITH l/r OVER 120

Safe loads on Columns with l/r over 120, pp. 211 to 233, are tabulated on the basis of reduced unit stresses applicable to main members (A.I.S.C. Spec. Sect. 16(b)), since the column sections are such that they would not often be used as bracing or as secondary members.

Conversely, the safe loads on angle struts which follow on pp. 235 to 247, are tabulated on the basis of the full unit stress (Sect. 15(a)(2)), since the sections are more often used as bracing and as secondary members than as main members.

By the use of the table of comparative unit stresses given below, a tabulated safe load for a main member may be changed to the safe load on the same member used as bracing or secondary; or vice versa; by a continuous slide-rule operation.

In so doing, column weights in the main member tables, pp. 211 to 233, may conveniently be transformed to areas by dividing by 3.4. The double-angle strut tables, however, pp. 235 to 247, show the areas and render this step unnecessary.

EXAMPLE 1. Reqd., Safe Load on 8 x 6½ WF @ 24, 20′ long, used as a bracing member.

Tabulated safe load on main member = 49 kips (Page 221).

$\frac{49 \times 3.4}{24} = 6.94$ in Col. II.; opposite in Col. I., f = 8.09 (by interpolation)

$49 \times \frac{8.09}{6.94} = 57$ kips.

EXAMPLE 2. Reqd., Safe Load on 2 angles 9 × 4 × ⅞, 9″ legs b. to b., 21′ long, used as a main column.

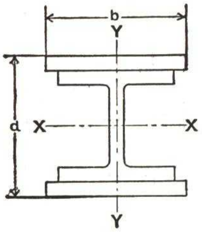
Tabulated safe load as a bracing member = 151 kips (Page 238).

$\frac{151}{21.22} = 7.11$ in Col. I.; opposite in Col. II., f = 5.47.

$151 \times \frac{5.47}{7.11} = 116$ kips.

ALLOWABLE STRESS PER SQ. IN., COMPRESSION MEMBERS WITH l/r OVER 120.

$\frac{l}{r}$	I. "f" for Secondary Members	II. "f" for Main Members	$\frac{l}{r}$	I. "f" for Secondary Members	II. "f" for Main Members	$\frac{l}{r}$	I. "f" for Secondary Members	II. "f" for Main Members	$\frac{l}{r}$	I. "f" for Secondary Members	II. "f" for Main Members
121	9.93	9.88	141	8.55	7.65	161	7.38	5.87	181	6.38	4.43
122	9.85	9.75	142	8.49	7.56	162	7.32	5.78	182	6.34	4.37
123	9.78	9.63	143	8.43	7.46	163	7.27	5.71	183	6.29	4.31
124	9.71	9.52	144	8.36	7.36	164	7.22	5.63	184	6.25	4.25
125	9.64	9.40	145	8.30	7.26	165	7.16	5.55	185	6.20	4.19
126	9.56	9.27	146	8.24	7.17	166	7.11	5.47	186	6.16	4.13
127	9.49	9.16	147	8.18	7.08	167	7.06	5.40	187	6.12	4.07
128	9.42	9.04	148	8.12	6.98	168	7.01	5.33	188	6.07	4.01
129	9.35	8.93	149	8.06	6.89	169	6.96	5.25	189	6.03	3.95
130	9.28	8.82	150	8.00	6.80	170	6.91	5.18	190	5.99	3.89
131	9.22	8.71	151	7.94	6.71	171	6.86	5.11	191	5.95	3.84
132	9.15	8.60	152	7.88	6.62	172	6.81	5.04	192	5.91	3.78
133	9.08	8.49	153	7.82	6.53	173	6.76	4.97	193	5.86	3.72
134	9.01	8.38	154	7.77	6.45	174	6.71	4.90	194	5.82	3.67
135	8.94	8.27	155	7.71	6.36	175	6.66	4.83	195	5.78	3.61
136	8.88	8.17	156	7.65	6.27	176	6.62	4.77	196	5.74	3.56
137	8.81	8.06	157	7.60	6.19	177	6.57	4.70	197	5.70	3.51
138	8.75	7.96	158	7.54	6.11	178	6.52	4.63	198	5.66	3.45
139	8.68	7.86	159	7.49	6.03	179	6.47	4.56	199	5.62	3.40
140	8.62	7.76	160	7.43	5.94	180	6.43	4.50	200	5.59	3.35



COVER PLATED

COLUMNS

ALLOWABLE CONCENTRIC LOADS IN KIPS

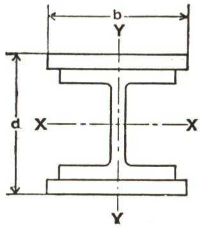
Unbraced Length Feet	14 WF 320 CORE SECTION — Cover Plates: Width and Thickness, Inches								
	24x3⅝	24x3½	24x3⅜	24x3¼	24x3⅛	24x3	23x3	23x2⅞	23x2¾
8	4526	4424	4323	4221	4120	4018	3915	3818	3720
9	4517	4415	4314	4213	4112	4010	3906	3810	3712
10	4507	4406	4305	4204	4103	4002	3897	3801	3703
11	4497	4396	4295	4193	4093	3992	3887	3791	3693
12	4485	4384	4283	4183	4082	3981	3875	3780	3682
13	4472	4372	4272	4171	4070	3970	3864	3768	3670
14	4459	4359	4258	4158	4058	3957	3850	3755	3658
15	4445	4344	4244	4144	4044	3944	3836	3741	3644
16	4429	4329	4229	4129	4029	3929	3821	3726	3630
17	4413	4312	4213	4113	4013	3913	3805	3710	3614
18	4395	4295	4196	4096	3997	3897	3788	3693	3597
19	4376	4277	4178	4079	3980	3880	3770	3676	3580
20	4357	4257	4159	4060	3961	3862	3751	3657	3561
21	4336	4237	4139	4041	3942	3843	3731	3637	3542
22	4314	4216	4118	4020	3921	3823	3710	3617	3522
23	4292	4194	4096	3998	3901	3802	3689	3595	3501
24	4268	4170	4074	3976	3879	3781	3665	3572	3478
25	4243	4146	4049	3952	3856	3758	3641	3548	3456
26	4218	4121	4024	3928	3832	3734	3616	3524	3432
27	4191	4095	3998	3903	3807	3710	3590	3499	3407
28	4163	4067	3972	3877	3781	3684	3564	3473	3382
29	4135	4040	3944	3849	3754	3658	3537	3446	3355
30	4105	4010	3916	3821	3726	3631	3507	3417	3327
32	4043	3948	3854	3761	3668	3573	3446	3357	3268
34	3976	3883	3791	3699	3605	3512	3383	3294	3206
36	3906	3813	3722	3632	3539	3447	3314	3226	3140
38	3832	3741	3651	3560	3471	3379	3243	3157	3071
40	3752	3662	3575	3485	3398	3307	3167	3081	2979
42	3671	3582	3494	3408	3320	3231	3088	3002	2920
44	3585	3496	3412	3325	3239	3151	3003	2919	2839
46	3493	3408	3323	3238	3154	3066	2915	2833	2754
48	3399	3316	3233	3148	3065	2979	2824	2742	2665
50	3301	3217	3136	3056	2973	2888	2728	2650	2573

Unbraced length with respect to least radius of gyration

PROPERTIES

	24x3⅝	24x3½	24x3⅜	24x3¼	24x3⅛	24x3	23x3	23x2⅞	23x2¾
Wt. per Foot	912	891	871	850	830	810	789	770	750
Depth d	24	23¾	23½	23¼	23	22¾	22¾	22½	22¼
Width b	24	24	24	24	24	24	23	23	23
Ratio r_x/r_y	1.50	1.49	1.49	1.48	1.47	1.47	1.52	1.51	1.50
Bending Factors B_x	.143	.144	.145	.146	.147	.148	.149	.150	.151
Bending Factors B_y	.322	.324	.327	.329	.332	.334	.346	.349	.352

COVER PLATED
COLUMNS
ALLOWABLE CONCENTRIC LOADS IN KIPS



14 WF 320 CORE SECTION

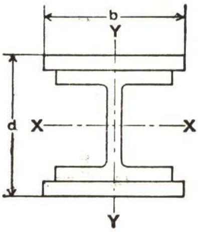
Cover Plates: Width and Thickness, Inches

Unbraced length with respect to least radius of gyration

Unbraced Length Feet	22x2¾	22x2⅝	22x2½	22x2⅜	22x2¼	22x2⅛	22x2	22x1⅞	22x1¾
8	3625	3532	3439	3346	3253	3160	3067	2974	2881
9	3617	3524	3431	3338	3245	3152	3060	2967	2874
10	3607	3514	3422	3329	3237	3144	3051	2958	2865
11	3597	3504	3412	3319	3227	3134	3042	2949	2857
12	3585	3493	3401	3308	3216	3124	3031	2939	2846
13	3573	3481	3389	3297	3204	3112	3020	2928	2835
14	3560	3468	3376	3284	3192	3100	3008	2916	2824
15	3545	3454	3362	3271	3179	3087	2995	2903	2812
16	3530	3439	3347	3256	3164	3073	2981	2890	2798
17	3513	3423	3331	3240	3149	3058	2967	2875	2784
18	3496	3405	3314	3224	3133	3042	2951	2860	2769
19	3477	3387	3297	3206	3116	3025	2935	2844	2753
20	3458	3368	3278	3188	3098	3007	2918	2827	2736
21	3438	3348	3258	3169	3079	2989	2899	2809	2718
22	3416	3327	3238	3149	3059	2969	2880	2790	2699
23	3394	3305	3216	3128	3038	2949	2860	2770	2680
24	3370	3282	3194	3106	3016	2928	2839	2750	2660
25	3346	3259	3170	3083	2993	2905	2817	2728	2639
26	3321	3234	3146	3058	2970	2882	2794	2705	2617
27	3295	3208	3120	3033	2946	2858	2771	2682	2594
28	3267	3181	3093	3007	2920	2833	2746	2658	2570
29	3239	3153	3065	2980	2894	2807	2721	2633	2546
30	3209	3124	3037	2953	2866	2781	2694	2607	2520
32	3148	3064	2978	2895	2809	2724	2639	2552	2466
34	3082	2999	2914	2833	2747	2664	2580	2494	2409
36	3014	2932	2847	2766	2683	2601	2518	2433	2349
38	2940	2860	2776	2697	2616	2533	2452	2369	2285
40	2862	2783	2701	2624	2543	2462	2382	2299	2217
42	2781	2703	2623	2547	2467	2387	2309	2228	2147
44	2695	2620	2540	2466	2387	2310	2232	2152	2072
46	2605	2532	2454	2380	2304	2228	2152	2072	1996
48	2513	2440	2364	2292	2216	2142	2067	1990	1914
50	2415	2344	2270	2200	2127	2054	1980	1905	1828

PROPERTIES

Wt. per Foot	731	713	694	675	657	638	619	601	582
Depth d	22¼	22	21¾	21½	21¼	21	20¾	20½	20¼
Width b	22	22	22	22	22	22	22	22	22
Ratio r_x/r_y	1.56	1.55	1.54	1.54	1.53	1.52	1.52	1.51	1.51
Bending Factors B_x	.152	.153	.154	.155	.156	.157	.159	.160	.161
Bending Factors B_y	.363	.366	.370	.374	.377	.382	.386	.391	.397



COVER PLATED COLUMNS

ALLOWABLE CONCENTRIC LOADS IN KIPS

14 WF 320 CORE SECTION

Cover Plates: Width and Thickness, Inches

Unbraced Length Feet (Unbraced length with respect to least radius of gyration)	22x1⅝	22x1½	20x1½	20x1⅜	20x1¼	18x1¼	18x1⅛	18x1
8	2788	2695	2590	2506	2422	2334	2259	2183
9	2781	2688	2583	2498	2414	2326	2251	2175
10	2773	2680	2574	2490	2406	2317	2242	2166
11	2764	2671	2564	2480	2397	2307	2232	2157
12	2754	2662	2554	2470	2386	2297	2221	2147
13	2743	2651	2543	2459	2375	2285	2210	2135
14	2732	2640	2530	2447	2364	2272	2197	2123
15	2720	2628	2517	2434	2351	2258	2184	2110
16	2706	2615	2503	2420	2337	2243	2169	2096
17	2692	2601	2488	2405	2323	2228	2154	2081
18	2678	2587	2472	2390	2308	2211	2138	2065
19	2662	2571	2455	2373	2291	2194	2121	2048
20	2645	2555	2437	2355	2274	2175	2103	2030
21	2628	2538	2418	2337	2256	2156	2083	2012
22	2610	2520	2399	2317	2238	2135	2063	1993
23	2590	2501	2379	2297	2218	2114	2043	1972
24	2570	2482	2357	2276	2197	2092	2021	1951
25	2550	2461	2335	2255	2176	2069	1998	1928
26	2528	2440	2312	2232	2154	2045	1975	1906
27	2506	2418	2288	2208	2130	2020	1950	1882
28	2482	2395	2263	2183	2106	1994	1924	1857
29	2458	2371	2237	2158	2080	1967	1898	1831
30	2433	2347	2209	2131	2054	1939	1870	1804
32	2380	2295	2153	2075	2000	1880	1813	1748
34	2324	2239	2094	2017	1942	1817	1751	1688
36	2265	2182	2029	1954	1881	1751	1687	1625
38	2202	2120	1962	1888	1816	1681	1618	1558
40	2135	2054	1890	1817	1748	1607	1545	1488
42	2066	1987	1816	1744	1676	1529	1469	1413
44	1994	1915	1738	1668	1601	1447	1390	1335
46	1918	1839	1655	1587	1522	1359	1302	1251
48	1838	1761	1570	1502	1437	1272	1218	1169
50	1755	1680	1476	1410	1349	1189	1138	1091

PROPERTIES

Wt. per Foot	563	544	524	507	490	473	458	442
Depth d	20	19¾	19¾	19½	19¼	19¼	19	18¾
Width b	22	22	20	20	20	18	18	18
Ratio r_x/r_y	1.50	1.50	1.59	1.58	1.58	1.66	1.65	1.64
Bending Factors B_x	.162	.164	.166	.168	.169	.172	.173	.175
Bending Factors B_y	.403	.410	.424	.430	.436	.439	.444	.449

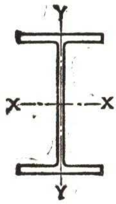
Loads below heavy lines are for main members with l/r ratios between 120 and 200.

14

COLUMNS

WF SHAPES

ALLOWABLE CONCENTRIC LOADS IN KIPS



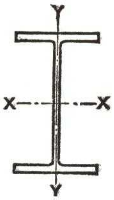
Unbraced Length Feet	Nominal Depth and Width—Weight per Foot								
	14 x 16								
	426	398	370	342	*320	314	287	264	246
6	2113	1973	1834	1696	1586	1556	1422	1308	1219
7	2107	1967	1829	1691	1582	1551	1418	1304	1215
8	2100	1960	1823	1685	1576	1546	1413	1299	1211
9	2092	1953	1816	1678	1569	1540	1407	1294	1206
10	2083	1945	1808	1671	1562	1533	1400	1288	1200
11	2073	1936	1799	1663	1554	1525	1393	1281	1194
12	2062	1925	1789	1654	1546	1516	1386	1274	1187
13	2051	1914	1779	1644	1536	1507	1377	1266	1179
14	2038	1902	1768	1633	1526	1497	1368	1258	1171
15	2025	1889	1755	1622	1515	1487	1358	1249	1163
16	2011	1876	1742	1610	1503	1476	1348	1239	1154
17	1995	1862	1729	1597	1491	1463	1337	1228	1144
18	1979	1846	1714	1584	1478	1450	1325	1217	1133
19	1962	1830	1699	1569	1464	1437	1312	1205	1122
20	1944	1813	1683	1554	1449	1423	1299	1193	1110
21	1925	1794	1666	1538	1434	1408	1285	1180	1098
22	1905	1775	1648	1521	1417	1392	1270	1166	1085
23	1884	1756	1629	1503	1400	1376	1255	1152	1072
24	1862	1736	1610	1485	1382	1359	1239	1137	1058
25	1839	1714	1589	1466	1364	1341	1223	1122	1044
26	1815	1691	1567	1446	1345	1322	1205	1106	1029
27	1790	1668	1545	1425	1324	1303	1187	1089	1013
28	1765	1643	1522	1404	1303	1283	1168	1071	996
29	1738	1619	1499	1381	1282	1261	1149	1053	979
30	1711	1593	1474	1358	1260	1240	1130	1035	962
32	1653	1538	1423	1310	1213	1195	1087	995	925
34	1593	1480	1367	1259	1163	1147	1043	954	886
36	1528	1419	1309	1203	1110	1095	995	910	844
38	1458	1354	1247	1146	1054	1041	945	863	800
40	1386	1285	1183	1085	995	984	892	814	753

Unbraced length with respect to least radius of gyration

PROPERTIES

Depth	18¾	18¼	18	17½	16¾	17¼	16¾	16½	16¼
Width	16¾	16⅝	16½	16⅜	16¾	16¼	16⅛	16	16
Ratio r_x/r_y	1.67	1.66	1.66	1.65	1.59	1.64	1.63	1.63	1.62
Bending Factors B_x	.177	.178	.179	.180	.191	.180	.181	.182	.182
Bending Factors B_y	.443	.447	.451	.456	.481	.459	.464	.467	.470

*Column Core Section.



COLUMNS

WF SHAPES

14

ALLOWABLE CONCENTRIC LOADS IN KIPS

Unbraced length with respect to least radius of gyration

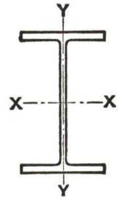
Unbraced Length Feet	Nominal Depth and Width—Weight per Foot									
	14 x 16									
	237	228	219	211	202	193	184	176	167	158
6	1174	1130	1084	1046	1001	956	911	871	827	783
7	1171	1126	1081	1042	998	953	908	868	824	780
8	1166	1122	1077	1038	994	949	904	865	821	777
9	1161	1117	1072	1034	989	945	900	861	817	774
10	1156	1112	1067	1029	984	940	896	857	813	770
11	1150	1106	1061	1024	979	935	891	852	809	766
12	1143	1100	1055	1018	973	930	886	847	804	761
13	1136	1093	1049	1011	967	924	880	842	799	756
14	1128	1086	1041	1004	960	917	874	836	793	750
15	1120	1078	1033	996	953	910	867	829	787	744
16	1111	1069	1025	988	945	903	860	822	780	738
17	1101	1060	1016	980	937	895	852	815	773	731
18	1091	1050	1007	971	928	886	844	807	765	724
19	1081	1040	997	961	919	877	836	799	757	717
20	1070	1029	986	951	909	868	827	790	749	709
21	1058	1017	975	940	899	858	817	781	741	701
22	1045	1005	963	928	888	848	807	771	731	692
23	1032	993	951	916	877	837	797	761	722	683
24	1019	980	938	904	865	825	786	751	712	673
25	1005	966	925	892	853	813	775	740	701	663
26	990	952	911	878	840	801	763	728	690	653
27	975	937	897	864	826	788	751	716	679	642
28	959	927	882	850	812	775	738	704	667	631
29	942	906	867	835	798	761	725	691	655	619
30	925	889	851	819	783	747	711	678	643	607
32	890	854	818	787	752	717	683	651	616	582
34	851	818	782	753	719	685	652	621	588	556
36	811	779	744	716	684	651	619	589	558	527
38	769	738	704	678	646	616	585	557	527	497
40	724	694	662	637	607	578	549	522	493	465

PROPERTIES

Depth	$16\frac{1}{8}$	16	$15\frac{7}{8}$	$15\frac{3}{4}$	$15\frac{5}{8}$	$15\frac{1}{2}$	$15\frac{3}{8}$	$15\frac{1}{4}$	$15\frac{1}{8}$	15
Width	$15\frac{7}{8}$	$15\frac{7}{8}$	$15\frac{7}{8}$	$15\frac{3}{4}$	$15\frac{3}{4}$	$15\frac{3}{4}$	$15\frac{5}{8}$	$15\frac{5}{8}$	$15\frac{5}{8}$	$15\frac{1}{2}$
Ratio r_x/r_y	1.62	1.61	1.62	1.61	1.61	1.61	1.61	1.60	1.60	1.60
Bending Factors B_x	.182	.182	.183	.183	.183	.183	.183	.184	.184	.183
Bending Factors B_y	.472	.473	.475	.477	.477	.479	.480	.483	.485	.485

14 I

COLUMNS
WF SHAPES



ALLOWABLE CONCENTRIC LOADS IN KIPS

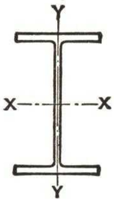
Unbraced length with respect to least radius of gyration

Unbraced Length Feet	Nominal Depth and Width—Weight per Foot									
	14 x 16			14 x 14½						
	150	142	*320	136	127	119	111	103	95	87
6	742	705	1586	673	628	589	549	509	470	430
7	740	702	1582	670	626	587	547	507	468	428
8	737	699	1576	667	623	584	545	505	466	426
9	734	696	1569	664	620	581	542	502	464	424
10	730	693	1562	660	616	578	539	499	461	422
11	726	689	1554	656	612	574	535	496	458	419
12	722	685	1546	651	608	570	531	493	455	416
13	717	680	1536	646	603	566	527	489	451	413
14	712	675	1526	641	598	561	523	485	447	409
15	706	670	1515	635	593	556	518	480	443	405
16	700	664	1503	629	587	551	513	475	439	401
17	694	658	1491	623	581	545	508	470	434	397
18	687	652	1478	616	575	539	502	465	429	392
19	680	645	1464	609	568	532	496	459	424	387
20	672	638	1449	601	561	525	490	453	418	382
21	664	630	1434	593	553	518	483	447	412	377
22	656	622	1417	585	545	511	476	441	406	372
23	647	614	1400	576	537	503	469	434	400	366
24	638	605	1382	567	528	495	461	427	393	360
25	629	596	1364	557	519	486	453	419	386	353
26	619	586	1345	547	510	477	444	411	379	346
27	609	576	1324	537	500	468	435	403	372	339
28	598	566	1303	526	490	459	426	395	364	332
29	587	555	1282	515	480	449	417	386	356	325
30	575	544	1260	503	469	438	408	377	347	317
32	552	522	1213	478	446	417	387	358	330	301
34	526	497	1163	453	421	394	366	338	311	284
36	499	471	1110	425	396	370	343	317	291	265
38	470	443	1054	395	368	343	317	293	269	246
40	439	414	995	365	339	317	293	270	249	226

PROPERTIES

	150	142	*320	136	127	119	111	103	95	87
Depth	14⅞	14¾	16¾	14¾	14⅝	14½	14⅜	14¼	14⅛	14
Width	15½	15½	16¾	14¾	14¾	14⅝	14⅝	14⅝	14½	14½
Ratio r_x/r_y	1.60	1.59	1.59	1.67	1.67	1.67	1.67	1.67	1.66	1.66
Bending Factors B_x	.184	.185	.191	.185	.185	.185	.185	.185	.186	.185
Bending Factors B_y	.487	.491	.481	.519	.520	.521	.525	.525	.529	.530

*Column Core Section.
Loads below heavy lines are for main members with l/r ratios between 120 and 200.



COLUMNS

WF SHAPES

14

ALLOWABLE CONCENTRIC LOADS IN KIPS

Unbraced Length Feet	14 x 12		14 x 10			14 x 8		
Nominal Depth and Width—Weight per Foot	84	78	74	68	61	53	48	43
6	413	384	361	332	297	254	230	206
7	411	382	358	329	295	251	227	203
8	408	379	354	325	292	246	223	199
9	405	376	350	321	288	241	218	195
10	401	372	345	317	284	235	213	190
11	397	368	340	312	280	229	207	185
12	393	364	334	307	275	222	201	179
13	388	360	328	301	270	215	194	173
14	383	355	321	295	264	207	187	166
15	378	350	314	288	258	199	179	159
16	372	344	307	281	252	190	171	152
17	366	338	299	273	245	180	162	144
18	359	332	290	265	238	169	152	135
19	352	326	281	257	230	158	142	126
20	345	319	271	248	222	146	131	116
21	337	312	261	238	213	135	121	107
22	329	304	250	228	204	125	112	98
23	320	296	239	218	195	115	104	90
24	311	288	228	207	185	106	95	83
25	302	279	215	195	174	97	87	77
26	292	270	202	184	164	90	80	70
27	282	260	190	172	154	82	74	64
28	272	250	179	162	144	75	67	59
29	261	240	168	152	135	69	61	54
30	250	230	157	142	127	63	56	49
32	226	207	139	125	112	52		
34	204	188	121	109	97			
36	184	169	106	96	85			
38	166	152	93	83	74			
40	149	136	80	72	64			

Unbraced length with respect to least radius of gyration

PROPERTIES

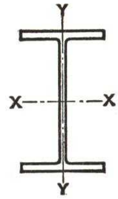
	84	78	74	68	61	53	48	43
Depth	14⅛	14	14¼	14	13⅞	14	13⅞	13⅝
Width	12	12	10⅛	10	10	8	8	8
Ratio r_x/r_y	2.03	2.03	2.44	2.45	2.44	3.07	3.07	3.08
Bending Factors B_x	.189	.189	.194	.194	.195	.200	.201	.202
Bending Factors B_y	.659	.665	.821	.830	.834	1.090	1.102	1.119

Loads below heavy lines are for main members with l/r ratios between 120 and 200.

12 I COLUMNS

WF SHAPES

ALLOWABLE CONCENTRIC LOADS IN KIPS



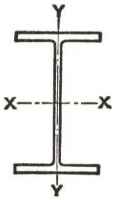
Unbraced Length Feet	Nominal Depth and Width—Weight per Foot 12 x 12										
	190	161	133	120	106	99	92	85	79	72	65
6	936	794	655	591	522	487	453	418	388	354	320
7	932	790	651	588	519	484	450	416	386	352	318
8	926	785	647	584	516	481	447	413	384	350	316
9	920	779	643	580	512	477	444	410	381	347	313
10	913	773	638	575	508	473	440	406	378	344	310
11	905	766	632	570	503	469	436	402	374	341	307
12	896	759	626	564	498	464	431	398	370	337	304
13	887	751	619	558	492	459	426	393	366	333	300
14	877	742	611	551	486	453	421	388	361	328	296
15	866	733	603	544	480	447	415	383	356	324	292
16	855	723	595	536	473	440	409	377	350	319	288
17	843	712	586	528	465	433	402	371	344	314	283
18	830	701	576	519	457	426	395	365	338	308	278
19	816	689	566	510	449	418	388	358	332	302	272
20	802	676	555	500	440	410	380	351	325	296	266
21	787	663	544	489	431	401	372	343	318	289	260
22	771	649	532	478	421	392	364	335	310	282	254
23	754	634	520	467	411	382	355	327	302	275	248
24	737	619	507	455	400	372	346	318	294	268	241
25	719	603	494	443	389	362	336	309	286	260	234
26	700	587	480	430	378	351	326	300	277	252	226
27	680	570	466	417	366	340	315	290	268	243	218
28	660	552	451	403	354	328	304	280	258	234	210
29	639	534	435	389	341	316	293	269	248	225	202
30	617	515	419	374	327	303	281	258	238	216	193
32	571	475	384	341	299	276	255	235	215	196	175
34	521	431	348	310	271	250	232	212	196	176	158
36	474	392	316	281	245	226	209	192	177	160	142
38	431	356	286	255	222	204	189	173	159	144	128
40	392	322	260	230	200	184	170	156	143	130	115

Unbraced length with respect to least radius of gyration

PROPERTIES

	190	161	133	120	106	99	92	85	79	72	65
Depth	$14\frac{3}{8}$	$13\frac{7}{8}$	$13\frac{3}{8}$	$13\frac{1}{8}$	$12\frac{7}{8}$	$12\frac{3}{4}$	$12\frac{5}{8}$	$12\frac{1}{2}$	$12\frac{3}{8}$	$12\frac{1}{4}$	$12\frac{1}{8}$
Width	$12\frac{5}{8}$	$12\frac{1}{2}$	$12\frac{3}{8}$	$12\frac{3}{8}$	$12\frac{1}{4}$	$12\frac{1}{4}$	$12\frac{1}{8}$	$12\frac{1}{8}$	$12\frac{1}{8}$	12	12
Ratio r_x/r_y	1.79	1.78	1.77	1.76	1.76	1.76	1.75	1.75	1.75	1.75	1.75
Bending Factors B_x	.212	.213	.214	.216	.216	.216	.216	.216	.217	.217	.217
Bending Factors B_y	.600	.610	.620	.631	.634	.637	.641	.642	.649	.653	.657

Loads below heavy lines are for main members with l/r ratios between 120 and 200.



COLUMNS

12-10

WF SHAPES

ALLOWABLE CONCENTRIC LOADS IN KIPS

Unbraced Length Feet	12 x 10		12 x 8			10 x 10	
Nominal Depth and Width—Weight per Foot	58	53	50	45	40	112	100
6	283	258	240	216	192	548	490
7	281	256	237	213	189	544	486
8	278	254	233	209	186	539	482
9	275	251	228	205	182	534	477
10	271	248	223	200	178	528	471
11	267	244	218	195	174	521	465
12	263	240	212	190	169	513	458
13	258	235	205	184	163	505	451
14	253	230	198	177	157	496	443
15	247	225	190	170	151	487	434
16	241	220	182	162	144	477	425
17	235	214	173	154	137	466	416
18	229	208	163	145	129	455	406
19	222	201	154	136	121	443	395
20	214	194	142	127	113	431	383
21	206	187	132	117	104	417	371
22	198	179	122	108	96	403	359
23	190	171	113	100	89	389	346
24	181	163	104	92	81	374	332
25	172	154	96	84	75	358	317
26	161	145	88	78	69	341	302
27	152	136	81	71	63	324	286
28	143	128	75	65	58	306	270
29	134	120	68	60	53	289	256
30	126	113	63	55	49	273	241
32	111	99	53	46	41	243	214
34	98	87				216	190
36	86	76				191	168
38	75	66				169	148
40	65	58				149	131

Unbraced length with respect to least radius of gyration

PROPERTIES

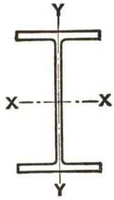
	58	53	50	45	40	112	100
Depth	$12\frac{1}{4}$	12	$12\frac{1}{4}$	12	12	$11\frac{3}{8}$	$11\frac{1}{8}$
Width	10	10	$8\frac{1}{8}$	8	8	$10\frac{3}{8}$	$10\frac{3}{8}$
Ratio r_x/r_y	2.10	2.11	2.64	2.65	2.64	1.75	1.74
Bending Factors B_x	.218	.221	.227	.227	.227	.261	.262
Bending Factors B_y	.797	.812	1.051	1.068	1.070	.728	.738

Loads below heavy line are for main members with l/r ratios between 120 and 200.

10 COLUMNS

WF SHAPES

ALLOWABLE CONCENTRIC LOADS IN KIPS



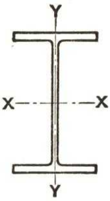
Unbraced Length Feet	Nominal Depth and Width—Weight per Foot									
	10 x 10							10 x 8		
	89	77	72	66	60	54	49	45	39	33
6	436	377	352	323	294	264	239	217	188	159
7	432	374	349	320	291	262	237	214	185	156
8	428	370	346	317	288	259	235	210	182	153
9	424	366	342	313	285	256	232	206	178	150
10	419	362	338	309	282	253	229	202	175	147
11	413	357	333	305	278	250	226	197	170	143
12	407	352	328	301	274	246	222	192	166	139
13	401	346	323	296	269	242	218	186	160	135
14	394	340	317	290	264	237	214	180	155	130
15	386	333	310	284	258	232	210	173	149	125
16	378	326	303	278	252	227	205	166	143	119
17	369	318	296	271	246	221	200	158	136	113
18	360	310	289	264	240	215	194	150	129	107
19	350	301	281	257	233	209	188	142	121	100
20	340	292	272	249	226	202	182	133	113	92
21	329	282	263	240	218	195	176	123	105	86
22	317	272	253	231	210	188	169	114	97	79
23	305	261	243	222	202	180	162	106	90	73
24	293	250	233	213	193	172	155	98	83	68
25	280	239	222	203	183	164	147	90	76	62
26	267	227	211	192	174	156	139	84	71	57
27	252	214	199	181	164	146	131	77	65	53
28	237	202	187	171	154	138	123	71	60	48
29	224	191	176	161	145	130	116	65	55	44
30	212	180	167	152	137	122	109	60	50	40
32	188	159	148	134	121	108	96	50	42	34
34	167	140	130	118	106	96	85			
36	147	124	115	105	94	84	74			
38	130	109	101	92	83	73	65			
40	113	95	88	80	72	64	57			

Unbraced length with respect to least radius of gyration

PROPERTIES

	89	77	72	66	60	54	49	45	39	33
Depth	$10\frac{7}{8}$	$10\frac{5}{8}$	$10\frac{1}{2}$	$10\frac{3}{8}$	$10\frac{1}{4}$	$10\frac{1}{8}$	10	$10\frac{1}{8}$	10	$9\frac{3}{4}$
Width	$10\frac{1}{4}$	$10\frac{1}{4}$	$10\frac{1}{8}$	$10\frac{1}{8}$	$10\frac{1}{8}$	10	10	8	8	8
Ratio r_x/r_y	1.73	1.73	1.72	1.72	1.72	1.71	1.71	2.17	2.16	2.16
Bending Factors B_x	.263	.263	.264	.263	.263	.263	.264	.270	.275	.277
Bending Factors B_y	.744	.753	.759	.761	.765	.767	.774	.995	1.025	1.055

Loads below heavy line are for main members with l/r ratios between 120 and 200.



COLUMNS

WF SHAPES

8

ALLOWABLE CONCENTRIC LOADS IN KIPS

Nominal Depth and Width—Weight per Foot

Unbraced Length Feet (Unbraced length with respect to least radius of gyration)	8 x 8						8 x 6½	
	67	58	48	40	35	31	28	24
6	324	280	232	193	169	149	132	113
7	320	277	229	190	167	147	129	111
8	315	273	225	187	164	145	126	108
9	310	268	221	184	161	142	122	105
10	304	263	217	180	158	139	118	101
11	298	257	212	176	154	136	114	97
12	291	251	207	172	150	132	108	93
13	283	244	201	167	146	128	103	88
14	275	237	195	161	141	124	96	83
15	266	229	189	155	136	120	90	77
16	256	221	182	149	131	115	83	71
17	246	212	174	143	125	110	77	65
18	236	202	166	136	119	104	69	59
19	224	192	158	129	112	98	64	54
20	212	182	149	121	105	92	58	49
21	200	171	139	112	98	86	52	44
22	186	159	129	105	91	79	47	40
23	174	148	120	97	84	73	43	36
24	161	137	112	89	78	68	39	32
25	150	128	104	83	72	62	35	29
26	139	118	96	77	67	57	31	26
27	129	109	89	71	62	53	28	
28	120	102	82	65	57	49		
29	111	94	76	61	52	46		
30	102	87	70	56	48	42		
31	95	80	64	51	44	38		
32	87	73	60	47	41	35		
33	81	68	54	43	37	32		
34	74	62	50	40				
35	68	57						

PROPERTIES

	67	58	48	40	35	31	28	24
Depth	9	8¾	8½	8¼	8⅛	8	8 1/16	7⅞
Width	8¼	8¼	8⅛	8⅛	8	8	6½	6½
Ratio r_x/r_y	1.75	1.74	1.74	1.73	1.72	1.73	2.13	2.12
Bending Factors B_x	.326	.328	.327	.331	.331	.333	.337	.339
Bending Factors B_y	.921	.937	.941	.972	.972	.991	1.244	1.261

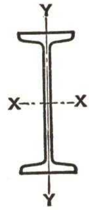
Loads below heavy line are for main members with l/r ratios between 120 and 200.

COLUMNS

AMERICAN STANDARD BEAMS

ALLOWABLE CONCENTRIC LOADS IN KIPS

I

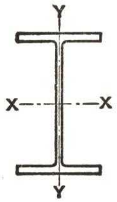


Unbraced Length Feet (Unbraced length with respect to least radius of gyration)	Nominal Depth and Width—Weight per Foot							
	6 x 3⅜		5 x 3		4 x 2¾		3 x 2⅜	
	17.25	12.5	14.75	10.0	9.5	7.7	7.5	5.7
2	82	59	70	47	45	36	35	26
3	79	56	66	45	42	34	32	24
4	73	54	61	41	38	30	28	21
5	66	49	54	37	33	26	23	18
6	58	44	46	32	26	22	17.2	13.4
7	48	38	36	26	20	16.6	12.6	9.9
8	38	31	28	20	15.2	12.7	9.1	7.3
9	31	25	22	15.3	11.4	9.5		
10	24	20	16.8	12.1				
11	18.3	15.7						
12		12						

PROPERTIES

Depth	6	6	5	5	4	4	3	3
Width	3⅝	3⅜	3¼	3	2¾	2⅝	2½	2⅜
Ratio r_x/r_y	3.35	3.42	2.97	3.15	2.69	2.78	2.21	2.32
Bending Factors B_x	.579	.497	.715	.593	.824	.737	1.124	.982
Bending Factors B_y	3.862	3.282	4.290	3.500	4.246	3.810	4.617	4.100

Loads below heavy line are for main members with l/r ratios between 120 and 200.



MISCELLANEOUS LIGHT COLUMNS

ALLOWABLE CONCENTRIC LOADS IN KIPS

I

Unbraced Length Feet	Nominal Depth and Width—Weight per Foot												
	8 x 8	6 x 6					6 x 4		5 x 5			4 x 4	
	*34.3	*25	‡25	*20	‡20	‡15.5	‡16	‡12	‡18.9	‡18.5	‡16	†13	°13
Unbraced length with respect to least radius of gyration													
4	168	121	122	97	97	76	75	55	89	89	77	60	61
5	166	119	120	95	96	75	71	52	86	87	75	57	58
6	164	116	117	92	94	73	67	49	83	84	72	54	55
7	162	113	114	89	91	71	63	45	80	81	70	50	52
8	159	109	111	86	89	69	57	41	76	78	67	46	48
9	155	105	107	83	85	66	51	35	71	74	63	40	43
10	151	100	103	79	82	63	44	29	66	69	59	34	37
11	147	95	98	74	78	60	37	25	61	65	55	30	32
12	143	89	93	69	74	56	32	20	55	59	50	25	27
13	138	83	88	64	69	53	27	17	48	53	44	21	23
14	132	76	82	58	64	48	22	14	42	47	39	17	19
15	126	68	75	52	59	43	19	11	37	41	35	15	16
16	120	61	68	46	53	39	15		32	37	30		14
17	113	55	61	41	48	35			28	32	27		
18	106	49	55	37	43	31			25	28	23		
19	98	43	50	33	39	28			21	25	20		
20	90	39	45	29	35	25			19	21	18		
21	83	34	40	25	31	22				19	15		
22	76	31	36	22	28	20							
23	70	27	32	20	25	17							
24	65		28		22	15							
25	59		25		19								
26	54												
27	49												
28	45												
29	41												
30	38												
31	34												

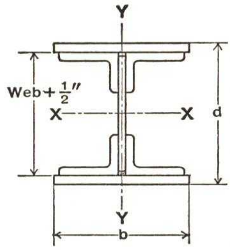
PROPERTIES

Depth	8	6	6⅜	6	6¼	6	6¼	6	5	5⅛	5	4	4⅛
Width	8	6	6	6	6	6	4	4	5	5	5	4	4
Ratio r_x/r_y	1.82	1.77	1.77	1.85	1.77	1.77	2.70	2.76	1.73	1.69	1.69	1.74	1.74
Bending Factors B_x	.346	.467	.439	.454	.440	.457	.467	.488	.576	.548	.551	.755	.701
Bending Factors B_y	1.136	1.466	1.316	1.542	1.341	1.444	2.206	2.451	1.765	1.540	1.567	2.245	2.065

*Rolled by United States Steel Corp., Inland Steel Co. and The Phœnix Iron Co.
†Rolled by United States Steel Corp.
‡Rolled by United States Steel Corp. and Bethlehem Steel Co.
°Rolled by Bethlehem Steel Co.
Loads below heavy line are for main members with l/r ratios between 120 and 200.

PLATE & ANGLE COLUMNS

ALLOWABLE CONCENTRIC LOADS IN KIPS



Web Plate		16 x $1\frac{3}{8}$								16 x $1\frac{1}{8}$		
4 Angles		8 x 8 x $1\frac{1}{8}$								8 x 8 x 1		
2 Cover Plates		24x$3\frac{3}{4}$	24x$3\frac{5}{8}$	24x$3\frac{1}{2}$	23x$3\frac{1}{2}$	23x$3\frac{3}{8}$	23x$3\frac{1}{4}$	23x$3\frac{1}{8}$	23x3	23x$3\frac{1}{8}$	23x3	22x3
Unbraced length in feet with respect to least radius of gyration	8	4538	4436	4335	4214	4117	4019	3923	3824	3740	3642	3538
	9	4529	4427	4326	4205	4108	4010	3914	3816	3732	3634	3530
	10	4519	4418	4316	4194	4098	4000	3904	3806	3723	3625	3520
	11	4508	4407	4306	4183	4087	3989	3893	3796	3713	3615	3510
	12	4496	4395	4294	4171	4075	3977	3882	3784	3702	3604	3498
	13	4483	4382	4282	4157	4062	3965	3869	3771	3690	3593	3486
	14	4469	4369	4268	4143	4047	3951	3855	3758	3677	3580	3473
	15	4454	4354	4253	4127	4032	3935	3840	3743	3663	3566	3458
	16	4438	4338	4237	4111	4016	3919	3824	3727	3649	3551	3442
	17	4420	4321	4221	4093	3998	3902	3807	3711	3633	3536	3426
	18	4402	4303	4203	4074	3980	3884	3789	3693	3616	3520	3409
	19	4383	4284	4185	4054	3960	3865	3770	3674	3598	3503	3390
	20	4363	4264	4165	4033	3939	3844	3750	3655	3580	3485	3371
	21	4341	4243	4143	4012	3918	3823	3729	3634	3561	3466	3351
	22	4319	4221	4122	3988	3895	3801	3707	3612	3540	3445	3329
	23	4295	4197	4099	3964	3871	3777	3684	3590	3519	3424	3307
	24	4271	4173	4075	3939	3846	3753	3660	3566	3496	3402	3284
	25	4245	4148	4051	3913	3820	3727	3635	3541	3473	3379	3260
	26	4219	4122	4025	3886	3794	3703	3609	3515	3448	3355	3234
	27	4191	4095	3998	3857	3766	3673	3582	3488	3423	3330	3207
	28	4162	4067	3970	3828	3736	3645	3554	3461	3397	3304	3180
	29	4132	4037	3940	3796	3706	3615	3525	3432	3370	3277	3151
	30	4102	4007	3911	3764	3675	3585	3494	3402	3342	3250	3122
	32	4037	3944	3849	3698	3610	3520	3430	3339	3282	3192	3061
	34	3968	3876	3781	3627	3540	3452	3363	3273	3219	3129	2996
	36	3895	3805	3711	3552	3466	3379	3291	3202	3152	3064	2925
	38	3818	3727	3636	3473	3388	3302	3215	3127	3082	2995	2851
	40	3737	3647	3556	3389	3305	3221	3135	3048	3008	2921	2774
	42	3651	3563	3474	3301	3218	3135	3051	2965	2930	2844	2693
	44	3561	3475	3387	3209	3127	3046	2963	2878	2848	2764	2608
	46	3467	3383	3294	3113	3032	2953	2871	2788	2763	2678	2516
	48	3369	3287	3200	3010	2933	2855	2774	2693	2671	2590	2424
	50	3267	3187	3101	2904	2829	2753	2674	2593	2578	2499	2326
PROPERTIES												
Wt. per Ft.		914	894	874	850	830	811	791	772	754	734	714
Depth d		24	$23\frac{3}{4}$	$23\frac{1}{2}$	$23\frac{1}{2}$	$23\frac{1}{4}$	23	$22\frac{3}{4}$	$22\frac{1}{2}$	$22\frac{3}{4}$	$22\frac{1}{2}$	$22\frac{1}{2}$
Width b		24	24	24	23	23	23	23	23	23	23	22
Ratio r_x/r_y		1.50	1.49	1.49	1.55	1.54	1.53	1.52	1.52	1.53	1.52	1.58
Bending Factors	B_x	.148	.149	.150	.151	.153	.154	.155	.156	.150	.152	.153
	B_y	.334	.336	.339	.354	.356	.359	.363	.366	.354	.357	.373

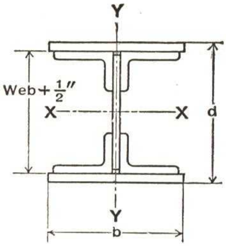


PLATE & ANGLE COLUMNS

ALLOWABLE CONCENTRIC LOADS IN KIPS

SHORT LEGS CONNECTED TO WEB

Web Plate	15 x 1											
4 Angles	8 x 6 x 1						8 x 6 x $\frac{7}{8}$			8 x 4 x 1		
2 Cover Plates	22x3⅛	22x3	22x2⅞	22x2¾	22x2⅝	22x2½	22x2½	22x2⅜	21x2⅜	20x2⅜	20x2¼	19x2¼
Unbraced length, in feet, with respect to least radius of gyration												
8	3447	3354	3261	3168	3075	2982	2880	2787	2706	2592	2507	2429
9	3439	3346	3254	3161	3068	2975	2874	2781	2699	2584	2500	2422
10	3430	3338	3245	3153	3060	2967	2866	2773	2691	2577	2492	2414
11	3421	3328	3236	3144	3052	2959	2858	2765	2682	2568	2484	2405
12	3410	3318	3226	3134	3042	2949	2848	2756	2673	2559	2475	2395
13	3399	3307	3215	3123	3031	2939	2838	2747	2663	2548	2464	2384
14	3386	3295	3203	3112	3020	2928	2828	2736	2652	2537	2454	2373
15	3373	3282	3190	3099	3007	2916	2817	2725	2640	2525	2442	2361
16	3359	3268	3176	3086	2994	2903	2804	2713	2627	2512	2429	2347
17	3344	3253	3162	3071	2980	2889	2791	2700	2614	2498	2416	2333
18	3328	3237	3147	3056	2966	2874	2777	2687	2600	2484	2402	2318
19	3311	3221	3130	3040	2950	2859	2763	2672	2584	2469	2387	2302
20	3293	3203	3113	3024	2934	2843	2747	2657	2568	2453	2371	2286
21	3274	3185	3095	3006	2916	2826	2731	2641	2552	2436	2354	2268
22	3255	3166	3076	2988	2898	2808	2714	2625	2534	2418	2337	2250
23	3234	3145	3057	2968	2879	2790	2696	2607	2515	2399	2319	2230
24	3213	3124	3036	2948	2859	2771	2678	2589	2496	2380	2300	2210
25	3190	3103	3014	2927	2838	2750	2659	2571	2476	2360	2280	2190
26	3167	3080	2992	2905	2817	2729	2639	2551	2456	2339	2259	2168
27	3143	3056	2968	2882	2794	2707	2618	2531	2434	2317	2238	2145
28	3118	3031	2944	2858	2771	2684	2596	2509	2412	2294	2216	2122
29	3092	3006	2919	2834	2747	2661	2573	2487	2388	2271	2193	2097
30	3065	2979	2893	2808	2722	2636	2550	2464	2364	2246	2169	2072
32	3008	2924	2839	2754	2670	2585	2501	2416	2313	2195	2119	2019
34	2948	2865	2781	2698	2614	2530	2449	2365	2259	2140	2065	1963
36	2884	2802	2718	2637	2554	2472	2394	2311	2203	2082	2009	1903
38	2816	2736	2654	2574	2491	2410	2336	2254	2142	2021	1949	1840
40	2745	2666	2586	2506	2426	2346	2274	2193	2078	1957	1885	1772
42	2670	2592	2512	2436	2357	2278	2210	2131	2011	1889	1819	1703
44	2591	2515	2437	2361	2283	2206	2141	2065	1940	1818	1750	1630
46	2509	2436	2358	2284	2208	2132	2070	1995	1868	1744	1676	1552
48	2423	2350	2274	2204	2128	2054	1997	1922	1791	1666	1600	1472
50	2333	2263	2189	2119	2045	1972	1919	1846	1710	1585	1522	1408

PROPERTIES

Wt. per Ft.	695	677	658	639	621	602	581	563	547	524	507	491
Depth d	21¾	21½	21¼	21	20¾	20½	20½	20¼	20¼	20¼	20	20
Width b	22	22	22	22	22	22	22	22	21	20	20	19
Ratio r_x/r_y	1.50	1.49	1.49	1.48	1.47	1.47	1.47	1.46	1.52	1.57	1.57	1.63
Bending Factors B_x	.154	.156	.157	.158	.159	.160	.158	.159	.160	.157	.158	.159
Bending Factors B_y	.352	.355	.358	.362	.365	.369	.364	.368	.383	.385	.389	.403

Loads below heavy line are for main members with l/r ratios between 120 and 200.

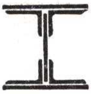
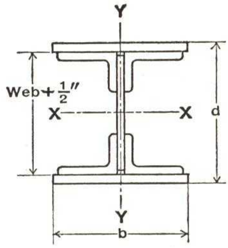


PLATE & ANGLE COLUMNS

ALLOWABLE CONCENTRIC LOADS IN KIPS

SHORT LEGS CONNECTED TO WEB



Web Plate	14 x 1		14 x 1⅛		14 x ¾			14 x 13/16		
4 Angles	8 x 4 x 1		8 x 4 x ⅞		8 x 4 x ⅞			8 x 4 x ⅞		
2 Cover Plates	19x2¼	18x2¼	18x2¼	18x2⅛	17x2¼	17x2	17x1¾	17x1⅝	17x1½	17x1⅜
Unbraced length, in feet, with respect to least radius of gyration										
8	2413	2334	2278	2202	2112	1969	1826	1771	1698	1627
9	2405	2327	2271	2195	2104	1962	1819	1764	1692	1621
10	2397	2318	2263	2187	2096	1954	1812	1757	1685	1614
11	2388	2309	2253	2178	2087	1945	1804	1749	1677	1606
12	2379	2299	2243	2168	2077	1936	1795	1740	1669	1598
13	2368	2287	2232	2158	2066	1926	1785	1731	1660	1589
14	2357	2275	2221	2146	2054	1915	1774	1720	1650	1579
15	2344	2263	2208	2134	2042	1903	1763	1709	1639	1569
16	2331	2249	2194	2120	2028	1890	1751	1697	1627	1558
17	2317	2234	2180	2106	2014	1876	1738	1684	1615	1546
18	2303	2218	2164	2091	1999	1862	1725	1671	1602	1533
19	2287	2202	2148	2076	1982	1847	1710	1657	1588	1520
20	2270	2184	2131	2059	1965	1830	1695	1642	1574	1506
21	2253	2166	2113	2041	1947	1814	1679	1626	1559	1491
22	2235	2147	2094	2023	1929	1796	1662	1610	1543	1476
23	2216	2127	2074	2004	1909	1777	1645	1593	1526	1459
24	2196	2106	2054	1984	1889	1758	1627	1575	1509	1442
25	2175	2083	2032	1963	1867	1738	1608	1556	1491	1425
26	2154	2060	2010	1941	1845	1717	1588	1536	1472	1407
27	2132	2037	1987	1918	1822	1695	1567	1516	1452	1388
28	2108	2013	1963	1895	1798	1672	1546	1495	1432	1368
29	2084	1987	1938	1870	1773	1649	1523	1473	1411	1347
30	2059	1960	1912	1845	1747	1624	1500	1451	1389	1326
32	2006	1905	1858	1792	1693	1573	1452	1403	1343	1281
34	1951	1846	1801	1736	1636	1519	1401	1353	1293	1234
36	1892	1784	1738	1676	1575	1461	1346	1299	1242	1184
38	1830	1717	1673	1612	1510	1400	1289	1242	1188	1130
40	1763	1648	1605	1546	1442	1336	1228	1183	1130	1074
42	1694	1574	1533	1476	1370	1268	1164	1120	1069	1015
44	1622	1498	1458	1402	1295	1197	1097	1052	1002	951
PROPERTIES										
Wt. per Ft.	488	473	461	446	428	399	371	359	345	330
Depth d	19	19	19	18¾	19	18½	18	17¾	17½	17¼
Width b	19	18	18	18	17	17	17	17	17	17
Ratio r_x/r_y	1.53	1.59	1.60	1.59	1.68	1.65	1.63	1.62	1.61	1.60
Bending Factors B_x	.170	.172	.171	.172	.168	.170	.173	.175	.176	.178
Bending Factors B_y	.400	.414	.416	.420	.422	.428	.435	.441	.446	.451

Loads below heavy line are for main members with l/r ratios between 120 and 200.

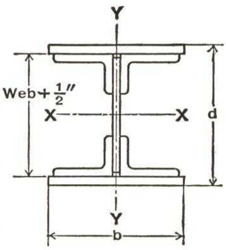
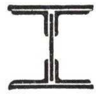


PLATE & ANGLE COLUMNS



ALLOWABLE CONCENTRIC LOADS IN KIPS

SHORT LEGS CONNECTED TO WEB

Web Plate	14 x 13/16		14 x ¾					14 x 11/16		14 x ⅝
4 Angles	8 x 4 x ⅞		8x4x¾	7x4x⅞	7 x 4 x ¾			7 x 4 x ¾		7x4x¾
2 Cover Plates	17x1¼	17x1⅛	16x1¼	16x1	16x1	16x⅞	16x13/16	16x¾	16x11/16	16x⅝
Unbraced length, in feet, with respect to least radius of gyration										
7	1561	1489	1415	1307	1228	1161	1127	1079	1045	997
8	1555	1484	1410	1301	1223	1156	1122	1074	1041	992
9	1549	1478	1404	1295	1217	1150	1117	1069	1035	987
10	1543	1472	1398	1288	1211	1144	1111	1063	1029	982
11	1535	1465	1390	1280	1203	1137	1104	1056	1023	975
12	1527	1457	1382	1272	1195	1129	1096	1049	1016	968
13	1519	1448	1374	1263	1187	1121	1088	1041	1008	961
14	1509	1439	1365	1254	1178	1112	1079	1033	1000	953
15	1499	1429	1355	1242	1168	1102	1070	1024	991	944
16	1489	1419	1344	1231	1157	1092	1059	1014	981	935
17	1477	1408	1333	1219	1146	1081	1048	1003	971	925
18	1465	1396	1321	1206	1134	1069	1037	992	960	914
19	1452	1383	1308	1193	1121	1057	1025	980	948	903
20	1438	1370	1295	1178	1108	1044	1012	968	936	892
21	1424	1356	1281	1163	1093	1030	998	955	923	879
22	1409	1342	1266	1148	1079	1016	984	942	910	866
23	1393	1327	1250	1131	1063	1001	970	927	896	853
24	1377	1311	1234	1114	1047	985	954	912	881	839
25	1360	1294	1217	1096	1030	969	938	897	866	824
26	1342	1277	1200	1077	1013	952	921	881	850	809
27	1323	1259	1182	1058	995	934	904	864	834	793
28	1304	1241	1163	1038	976	916	886	847	817	776
29	1284	1222	1143	1017	956	897	867	829	799	759
30	1264	1202	1123	996	936	877	848	810	780	741
32	1220	1160	1080	950	893	836	807	770	741	704
34	1174	1115	1035	902	848	792	764	729	700	664
36	1126	1068	987	851	800	745	717	685	657	623
38	1074	1018	936	797	749	696	667	636	608	576
40	1019	966	883	738	693	642	616	587	561	531

PROPERTIES

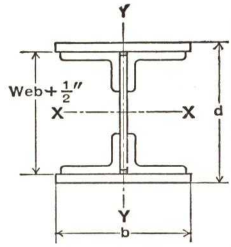
Wt. per Ft.	316	301	287	265	249	236	229	219	212	202
Depth d	17	16¾	17	16½	16½	16¼	16⅛	16	15⅞	15¾
Width b	17	17	16	16	16	16	16	16	16	16
Ratio r_x/r_y	1.60	1.59	1.67	1.74	1.75	1.75	1.75	1.75	1.75	1.75
Bending Factors B_x	.180	.181	.178	.184	.181	.184	.185	.185	.186	.186
Bending Factors B_y	.457	.464	.466	.538	.538	.552	.559	.563	.573	.578

Loads below heavy line are for main members with l/r ratios between 120 and 200.

PLATE & ANGLE COLUMNS

ALLOWABLE CONCENTRIC LOADS IN KIPS

SHORT LEGS CONNECTED TO WEB



Web Plate	14x9/16	14x5/8	14x9/16	14 x 1/2				14x3/8	14x1/2	14x3/8	14x1/2
4 Angles	7x4x3/4	7x4x5/8	7x4x5/8	7 x 4 x 5/8			7x4x9/16	7x4x7/8	7x4x3/4	7x4x3/4	7x4x5/8
2 Cover Plates	16 x 9/16	16 x 5/8	16 x 9/16	16 x 1/2	15 x 7/16	15 x 3/8	15 x 3/8				
Unbraced length, in feet, with respect to least radius of gyration											
7	949	915	867	819	770	738	697	678	629	600	548
8	944	912	863	815	766	734	694	674	625	596	545
9	939	907	859	811	762	730	690	670	621	592	541
10	934	901	854	806	757	725	685	665	616	588	536
11	928	895	848	801	751	720	680	659	611	583	531
12	921	889	842	795	745	714	674	653	605	577	526
13	914	882	835	789	739	708	668	647	598	571	520
14	906	875	828	782	732	701	662	639	591	565	513
15	898	867	821	775	724	693	655	632	584	557	506
16	889	858	813	767	716	685	647	624	576	550	499
17	879	849	804	759	707	677	639	615	568	542	491
18	869	839	794	750	698	668	631	606	559	534	483
19	859	829	785	741	688	658	622	596	549	525	474
20	847	819	774	731	678	648	612	586	539	515	465
21	835	807	764	720	668	638	602	575	529	505	455
22	823	795	752	710	657	627	592	563	518	495	445
23	810	783	740	698	645	616	581	552	506	484	435
24	796	770	728	686	632	603	569	539	494	473	424
25	782	756	715	674	620	591	557	526	481	461	412
26	768	742	701	661	606	578	545	513	468	449	400
27	752	728	687	648	593	564	532	499	454	436	387
28	736	713	673	634	578	550	519	485	440	423	374
29	720	697	658	619	563	535	505	469	425	409	361
30	703	681	642	605	548	521	490	453	410	395	347
32	667	646	609	574	516	488	460	421	378	365	316
34	629	610	575	540	481	455	428	385	343	332	287
36	588	571	538	505	443	418	392	350	312	302	260
38	553	529	497	465	405	380	358	319	283	275	235
40	527	488	458	431	371	356	328	290	256	249	212

PROPERTIES

Wt. per Ft.	192	186	176	166	157	150	142	139	128	123	112
Depth d	15 5/8	15 3/4	15 5/8	15 1/2	15 3/8	15 1/4	15 1/4	14 1/2	14 1/2	14 1/2	14 1/2
Width b	16	16	16	16	15	15	15	14 3/8	14 1/2	14 3/8	14 1/2
Ratio r_x/r_y	1.75	1.76	1.76	1.77	1.83	1.84	1.84	1.84	1.87	1.88	1.91
Bending Factors B_x	.186	.183	.183	.183	.186	.188	.187	.198	.203	.197	.204
Bending Factors B_y	.585	.579	.585	.592	.610	.624	.627	.669	.710	.690	.746

Loads below heavy line are for main members with l/r ratios between 120 and 200.

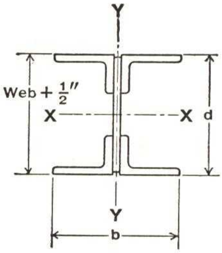


PLATE & ANGLE COLUMNS

ALLOWABLE CONCENTRIC LOADS IN KIPS

SHORT LEGS CONNECTED TO WEB

Web Plate	14 x 3/8									14 x 5/16	
4 Angles	7x4x9/16	7x4x1/2	6x4x1/2	6x4x7/16	5x3½x½	5x3½x7/16	5x3½x3/8	4x3x7/16	4x3x3/8	4x3x3/8	4x3x5/16
Unbraced length, in feet, with respect to least radius of gyration											
7	478	437	400	362	345	314	282	262	237	224	198
8	475	434	396	358	340	309	277	256	230	218	193
9	472	431	391	354	334	303	272	248	223	211	186
10	468	427	387	349	328	297	266	239	215	204	179
11	463	423	381	344	321	291	260	230	206	195	171
12	459	418	375	339	313	283	253	219	196	186	163
13	454	414	369	333	305	275	246	208	185	176	153
14	448	408	362	326	296	267	238	196	173	166	143
15	442	403	355	319	286	258	229	183	161	154	132
16	436	397	347	312	276	248	219	169	147	141	120
17	429	390	338	304	265	237	209	153	134	128	108
18	422	384	329	295	253	226	199	140	121	116	98
19	414	377	320	286	241	214	188	126	110	106	88
20	406	369	310	277	228	202	176	115	99	96	80
21	397	361	299	267	214	188	163	104	89	86	72
22	389	353	288	257	199	174	150	94	80	78	64
23	379	344	277	246	185	162	140	84	73	70	57
24	370	335	265	234	172	150	129	76	65	63	51
25	360	326	252	222	160	139	119	68	58	56	46
26	349	316	238	209	148	129	110	61	52	50	
27	338	305	224	197	137	119	102				
28	327	295	211	185	127	110	94				
29	315	284	199	174	118	101	86				
30	303	272	187	164	109	93	79				
31	290	260	176	154	100	86	72				
32	276	247	166	144	92	79	66				
33	263	235	156	135	85	72	61				
34	250	224	146	127	78	67					
35	238	213	137	119	72						
36	227	202	129	111							
38	205	183	113	97							
40	185	165	99	84							

PROPERTIES

Wt. per Ft.	97.9	89.5	82.7	75.1	72.3	65.9	59.5	57.1	51.9	48.9	43.7
Depth d	14½	14½	14½	14½	14½	14½	14½	14½	14½	14½	14½
Width b	14 3/8	14 3/8	12 3/8	12 3/8	10 3/8	10 3/8	10 3/8	8 3/8	8 3/8	8 5/16	8 5/16
Ratio r_x/r_y	1.94	1.96	2.31	2.35	2.81	2.86	2.91	3.63	3.69	3.70	3.77
Bending Factors B_x	.198	.200	.205	.207	.207	.209	.212	.212	.216	.210	.215
Bending Factors B_y	.736	.756	.939	.978	1.165	1.222	1.283	1.608	1.705	1.635	1.745

Loads below heavy line are for main members with l/r ratios between 120 and 200.

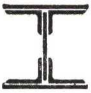
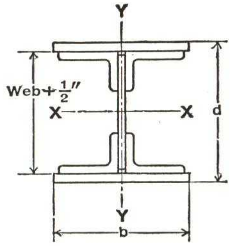


PLATE & ANGLE COLUMNS

ALLOWABLE CONCENTRIC LOADS IN KIPS

SHORT LEGS CONNECTED TO WEB



Web Plate		12 x 3/4		12 x 5/8	12 x 9/16	12 x 1/2				12 x 3/8	
4 Angles		6x4x3/4	6x4x5/8	6x4x5/8	6x4x5/8	6x4x5/8	6x4x9/16	6x4x5/8	6x4x9/16	6x4x9/16	6x4x1/2
2 Cover Plates		13 x 3/4	13 x 3/4	13 x 5/8	13 x 1/2	13 x 3/8	13 x 5/16				
Unbraced length, in feet, with respect to least radius of gyration	7	936	864	785	718	651	587	486	449	425	388
	8	930	859	780	713	646	582	482	445	421	384
	9	923	852	774	707	641	577	477	440	417	380
	10	916	845	767	701	635	572	471	435	412	375
	11	907	837	760	694	629	566	465	429	406	370
	12	897	828	752	687	621	559	458	423	400	365
	13	887	819	743	678	614	552	451	416	394	359
	14	876	809	733	669	605	544	443	408	387	352
	15	864	798	723	660	596	535	435	400	380	345
	16	852	786	712	650	586	526	425	392	372	338
	17	838	773	701	639	576	517	416	382	363	330
	18	824	760	688	627	565	507	406	373	354	321
	19	809	746	675	615	554	496	395	362	344	312
	20	793	731	662	602	542	484	383	351	334	303
	21	776	715	647	588	529	473	371	340	324	293
	22	758	699	632	574	515	460	359	328	313	283
	23	740	682	616	559	501	447	346	315	301	272
	24	721	664	600	544	486	433	332	302	289	261
	25	701	645	582	528	471	419	318	288	276	249
	26	680	626	564	511	455	404	303	274	263	237
	27	658	606	546	493	438	389	286	258	248	223
	28	636	585	526	475	421	373	270	244	235	210
	29	613	564	506	456	403	356	255	230	222	198
	30	589	541	485	437	384	337	241	216	209	187
	31	564	516	463	415	365	320	227	204	197	176
	32	536	492	440	395	347	304	214	192	185	165
	33	510	468	419	375	329	288	202	180	175	156
	34	486	446	398	357	312	273	190	170	164	146
	35	462	424	379	339	296	259	178	159	155	137
	36	439	403	360	322	281	245	168	150	145	129
	38	397	364	325	289	252	220	148	132	128	113
	40	358	328	292	260	226	196	130	115	112	99

PROPERTIES

Wt. per Ft.	191	177	161	147	134	120	100	92.8	87.7	80.1
Depth d	14	14	13¾	13½	13¼	13⅛	12½	12½	12½	12½
Width b	13	13	13	13	13	13	12½	12½	12⅜	12⅜
Ratio r_x/r_y	1.79	1.82	1.82	1.82	1.83	1.84	1.89	1.92	1.92	1.94
Bending Factors B_x	.225	.223	.222	.224	.227	.228	.248	.249	.242	.243
Bending Factors B_y	.677	.682	.694	.715	.741	.766	.892	.917	.887	.910

Loads below heavy line are for main members with l/r ratios between 120 and 200.

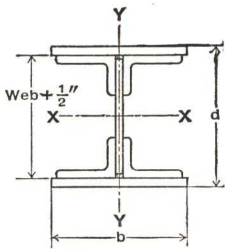
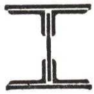


PLATE & ANGLE COLUMNS



ALLOWABLE CONCENTRIC LOADS IN KIPS

SHORT LEGS CONNECTED TO WEB

Web Plate	12 x 3/8			12 x 5/16					10 x 1/2	10 x 7/16	
4 Angles	6x4x7/16	6x4x3/8	5x3½x7/16	5x3½x7/16	5x3½x3/8	4x3x7/16	4x3x3/8	4x3x5/16	5x3½x5/8	5x3½x5/8	5x3½x½
2 Cover Plates									11 x 11/16	11 x 9/16	11 x 9/16
Unbraced length, in feet, with respect to least radius of gyration											
7	350	312	302	290	259	240	215	189	657	601	540
8	346	309	298	286	255	234	209	184	651	595	535
9	342	305	293	282	250	228	203	178	644	589	529
10	338	301	287	276	245	221	196	172	637	581	523
11	333	297	281	270	240	213	189	165	628	573	516
12	328	292	274	264	234	204	181	157	619	565	508
13	323	286	267	257	228	194	172	149	609	555	500
14	316	281	259	250	221	184	162	140	598	545	490
15	310	275	250	242	213	173	152	130	586	534	481
16	303	268	241	233	205	161	140	118	574	522	470
17	295	261	231	224	197	148	128	107	561	510	459
18	287	254	221	215	188	135	116	97	547	496	447
19	279	246	210	205	178	123	106	88	532	482	435
20	270	238	199	194	168	112	96	80	516	467	421
21	261	229	186	182	157	102	87	72	500	452	408
22	251	220	173	170	146	93	79	65	482	436	393
23	241	211	161	158	135	84	71	58	464	419	378
24	230	201	149	147	126	76	64	52	445	401	362
25	219	191	139	137	117	68	58	47	425	382	345
26	207	179	129	127	108	62	52	42	405	362	328
27	195	169	119	118	100	56	46		382	342	308
28	184	159	110	109	92				361	322	292
29	173	149	102	101	85				340	303	274
30	163	140	94	93	79				322	285	258
31	153	132	87	86	72				302	269	244
32	144	123	80	80	67				285	253	230
33	135	116	74	73	61				268	238	216
34	127	108	68	68	56				252	223	203
35	119	101	62	62					237	209	190
36	111	95							223	197	179
38	98	83							196	173	157
40	85	72							173	151	138

PROPERTIES

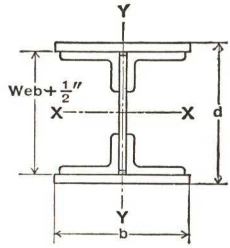
Wt. per Ft.	72.5	64.5	63.3	60.8	54.4	52.0	46.8	41.6	136	124	111
Depth d	12½	12½	12½	12½	12½	12½	12½	12½	11⅞	11⅝	11⅝
Width b	12⅜	12⅜	10⅜	10 5/16	10 5/16	8 5/16	8 5/16	8 5/16	11	11	11
Ratio r_x/r_y	1.98	2.01	2.41	2.40	2.44	3.05	3.10	3.17	1.81	1.81	1.82
Bending Factors B_x	.244	.246	.245	.239	.242	.241	.244	.249	.263	.266	.259
Bending Factors B_y	.945	.983	1.174	1.141	1.188	1.492	1.564	1.660	.794	.816	.814

Loads below heavy line are for main members with l/r ratios between 120 and 200.

PLATE & ANGLE COLUMNS

ALLOWABLE CONCENTRIC LOADS IN KIPS

SHORT LEGS CONNECTED TO WEB



Web Plate	10 x 3/8			10 x 5/16		10 x 1/4				
4 Angles	5 x 3½ x ½		5x3½x5/8	5x3½x½	5x3½x7/16	5x3½x3/8	4x3x7/16	4x3x3/8	4x3x5/16	4x3x1/4
2 Cover Plates	11 x 7/16	11 x 5/16								
Unbraced length, in feet, with respect to least radius of gyration										
7	484	438	382	312	281	239	222	196	171	145
8	479	433	378	308	277	236	217	192	167	141
9	474	428	372	303	272	232	211	187	162	137
10	468	422	366	298	267	228	205	181	157	132
11	461	416	359	292	262	223	198	174	151	127
12	454	409	352	285	256	218	190	167	144	121
13	446	402	344	279	250	212	182	160	137	115
14	438	394	335	271	243	206	173	152	130	108
15	428	385	326	263	235	200	163	143	122	101
16	419	375	316	255	227	193	153	133	113	93
17	408	365	305	245	219	186	142	123	104	84
18	397	355	294	236	210	178	130	112	94	76
19	386	344	282	226	200	170	119	102	86	69
20	373	332	269	215	190	161	109	93	78	62
21	360	319	256	204	179	152	99	85	71	56
22	347	306	242	192	168	141	90	77	64	51
23	333	293	226	178	156	132	82	70	58	46
24	318	279	211	166	145	123	75	64	53	42
25	302	263	197	155	135	114	68	57	47	37
26	285	247	185	145	126	106	61	52	42	33
27	269	233	172	134	117	99	55	47	38	
28	253	219	160	125	108	91	50	42		
29	238	205	149	116	100	85				
30	224	192	139	108	93	78				
31	211	181	129	100	86	73				
32	198	169	120	93	80	67				
33	186	159	111	86	73	62				
34	174	148	103	79	68	57				
35	163	139	96	73	62	52				
36	153	130	88	67	57					
37	143	121	81							
38	134	113								
40	117	98								
PROPERTIES										
Wt. per Ft.	99.9	90.5	80.0	65.0	58.6	50.1	47.7	42.5	37.3	31.7
Depth d	11⅜	11⅛	10½	10½	10½	10½	10½	10½	10½	10½
Width b	11	11	10⅜	10 5/16	10 5/16	10¼	8¼	8¼	8¼	8¼
Ratio r_x/r_y	1.83	1.83	1.87	1.93	1.96	1.99	2.49	2.53	2.58	2.63
Bending Factors B_x	.262	.269	.298	.292	.292	.287	.286	.287	.291	.297
Bending Factors B_y	.843	.893	1.028	1.064	1.101	1.111	1.393	1.447	1.513	1.611

Loads below heavy line are for main members with l/r ratios between 120 and 200.

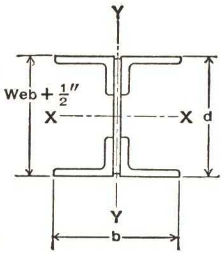


PLATE & ANGLE COLUMNS

ALLOWABLE CONCENTRIC LOADS IN KIPS

SHORT LEGS CONNECTED TO WEB

Web Plate	8 x 3/8		8 x 5/16		8 x 1/4			
4 Angles	4 x 3 x 5/8	4 x 3 x 1/2	4 x 3 x 7/16	4 x 3 x 3/8	4 x 3 x 5/16	4 x 3 x 1/4	3x2 1/4x5/16	3x2 1/2x1/4
Unbraced length, in feet, with respect to least radius of gyration								
5	312	263	230	204	170	143	134	114
6	307	259	226	200	167	141	130	110
7	302	254	222	197	164	138	125	106
8	296	249	217	192	160	135	119	100
9	289	243	212	187	156	131	112	94
10	282	236	205	181	151	126	105	87
11	273	229	199	175	146	122	97	80
12	264	221	191	168	140	117	88	71
13	254	212	183	161	133	111	78	63
14	243	202	174	153	126	105	68	55
15	232	192	165	144	119	98	60	48
16	220	181	155	135	111	91	53	42
17	206	169	145	125	102	83	46	37
18	192	156	133	115	94	76	40	31
19	177	143	122	104	86	69	35	27
20	162	131	111	96	78	63	30	
21	149	120	101	87	71	57		
22	137	110	92	79	64	52		
23	126	101	84	72	58	47		
24	115	91	77	65	53	42		
25	105	83	70	59	48	38		
26	96	76	63	53	43	34		
27	87	69	57	48	39	31		
28	79	62	51	43	35			
29	72	56	46					
30	65							

PROPERTIES

Wt. per Foot	64.6	54.6	47.7	42.5	35.6	30.0	29.2	24.8
Depth d	8 1/2	8 1/2	8 1/2	8 1/2	8 1/2	8 1/2	8 1/2	8 1/2
Width b	8 3/8	8 3/8	8 5/16	8 5/16	8 1/4	8 1/4	6 1/4	6 1/4
Ratio r_x/r_y	1.82	1.89	1.94	1.96	2.00	2.04	2.67	2.73
Bending Factors B_x	.385	.382	.375	.376	.371	.374	.384	.390
Bending Factors B_y	1.263	1.337	1.370	1.421	1.442	1.525	2.054	2.196

Loads below heavy line are for main members with l/r ratios between 120 and 200.

SINGLE AND DOUBLE ANGLE STRUTS

Allowable loads on single-angle struts are not tabulated in this Manual because it is virtually impossible to load such struts concentrically; it could in theory be accomplished by milling the ends of an angle and loading it through bearing plates; in practice the actual eccentricity of loading is relatively large, and its neglect in design may lead to considerable danger.

A satisfactorily approximate procedure is to compute the bending stress from the actual eccentricity as scaled from a sketch, locating the center of gravity and the diagonal (principal) axes of the angle by the right-hand columns in the tables of Properties of Angles, pages 34 to 37, and placing the applied forces at the centers of the rivets, bolts or welds; and then to apply the Specification rule for combined axial and bending stress (Sect. 12(a)), as exemplified on page 208.

In designing struts of two angles connected to opposite faces of a gusset plate, it is customary to neglect any eccentricity between the rivet gage line and the gravity axis of the strut. This has been done in the following tables of "Allowable Concentric Loads on Double-Angle Struts".

These tables have been cast in a form believed to be new. Each angle size is tabulated on a different set of lengths than its neighbors, in order (1) to locate more precisely the length at which $l/r = 120$ and 200, and (2) to facilitate accurate interpolation for lengths which the page size forbids tabulating. A dash line indicates the greatest center to center length in feet for which l/r is not over 120; and a solid line, 200. An experienced designer will, in interpolating, recall that the curve of unit stress is convex upward for $l/r = 0$ to 120, and convex downward thereafter.

The Institute will appreciate comment upon these tables, after they have been in use over a trial period.

Tabulated capacities for struts with l/r over 120 are applicable to bracing and secondary members only (Specification Section 16(a)). For such struts used as main members, the tabulated loads must be reduced as illustrated on Page 210 (Specification Section 16(b)).

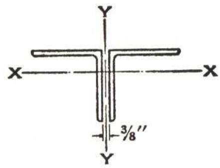
The tabulated capacities of double-angle struts, referred to the Y-Y axis, assume gussets $\frac{3}{8}''$ thick. The effect on l/r of varying the gusset thickness is slight. If $\frac{1}{2}''$ gussets are used, it is sufficiently accurate to increase the tabulated capacity on the Y-Y axis, when the length exceeds 10 feet, by the arbitrary fraction

$$\frac{\text{length in ft.} - 10}{2000}$$

Transverse to the plane of a gusset plate the actual fixation of a strut is frequently less than the column formula, on which the strut tables are based, presumes: and for such construction the tabulated safe loads should be regarded as ideal limits and should be reduced in practice.

The tabulated properties of two angles, on pages 123 to 127, will be found useful when designing struts of this type in accordance with any particular conception of the loading conditions.

Unit stresses for all types of compression members under concentric load, are tabulated on page 209.



DOUBLE-ANGLE STRUTS

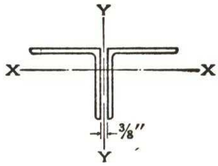
ALLOWABLE CONCENTRIC LOADS IN KIPS

Size	8 x 8						
Thickness	1 1/8	1	7/8	3/4	5/8	9/16	1/2
r_{xx}	2.42	2.44	2.45	2.47	2.49	2.50	2.50
r_{yy}	3.55	3.53	3.51	3.49	3.47	3.46	3.45
Wt. 2 ∟s	113.8	102.0	90.0	77.8	65.4	59.2	52.8
Area 2 ∟s	33.46	30.00	26.46	22.88	19.22	17.36	15.50
Axis X-X — Unsupported length in feet							
0	569	510	450	389	327	295	264
10	529	475	419	363	305	276	246
14	491	441	389	338	284	257	230
18	440	396	350	304	257	232	207
22	376	340	301	262	222	201	180
23	358	324	287	251	212	192	172
24	339	307	272	238	202	183	164
25	324	293	260	226	192	174	155
28	290	263	233	203	172	156	140
32	251	227	202	176	149	135	121
36	218	197	175	153	129	118	105
40	188	171	152	133	113	102	91
41				129	109	99	88
Axis Y-Y — Unsupported length in feet							
0	569	510	450	389	327	295	264
10	550	493	435	376	316	285	254
15	527	472	416	359	302	272	243
20	495	443	390	336	282	254	227
25	453	405	356	307	257	232	207
30	402	359	315	271	226	204	182
34	354	316	276	237	198	178	158
35	341	304	266	228	191	172	153
40	298	266	234	200	167	151	134
45	263	235	206	177	147	133	118
50	233	208	182	156	130	117	104
55	206	184	161	138	115	103	92
56	201	179	157	135	112	100	90
57	196	175	153	131	110	98	87
58	192	171	149	128			
59	188						

Size	6 x 6							
Thickness	1	7/8	3/4	5/8	9/16	1/2	7/16	3/8
r_{xx}	1.80	1.81	1.83	1.84	1.85	1.86	1.87	1.88
r_{yy}	2.72	2.70	2.68	2.66	2.65	2.64	2.63	2.62
Wt. 2 ∟s	74.8	66.2	57.4	48.4	43.8	39.2	34.4	29.8
Area 2 ∟s	22.00	19.46	16.88	14.22	12.86	11.50	10.12	8.72
Axis X-X — Unsupported length in feet								
0	374	331	287	242	219	195	172	148
8	344	304	264	223	202	181	159	137
10	327	289	252	212	192	172	152	131
12	306	271	236	200	181	162	143	123
14	281	249	218	184	167	150	132	114
16	253	225	197	167	152	136	120	104
18	220	196	173	147	134	120	106	92
22	180	160	140	120	109	97	87	75
26	148	132	116	99	90	81	71	62
30	123	110	96	82	74	67	60	51
31						64	57	49
Axis Y-Y — Unsupported length in feet								
0	374	331	287	242	219	195	172	148
10	353	312	271	228	206	184	161	139
12	344	304	263	222	200	179	157	135
14	333	294	255	214	193	173	152	131
16	321	283	245	206	186	166	146	126
18	307	270	234	196	177	158	138	119
20	291	256	221	186	166	149	131	113
22	273	241	208	174	157	140	122	105
24	254	223	192	161	145	129	113	97
26	234	205	176	147	132	118	103	88
27	223	195	168	140	126	113	99	85
30	200	176	152	127	114	102	89	77
34	176	154	133	111	100	89	78	67
38	154	135	116	97	87	78	68	58
42	136	120	102	85	77	68	60	51
43	132	116	99	83	74	66	58	50
44	128	112	96	80	72	64		
45	124	108						

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.

DOUBLE-ANGLE STRUTS



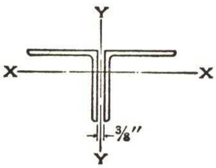
ALLOWABLE CONCENTRIC LOADS IN KIPS

Axis	Unsupported length in feet	5 x 5, 7/8	5 x 5, 3/4	5 x 5, 5/8	5 x 5, 1/2	5 x 5, 7/16	5 x 5, 3/8
r_{xx}		1.49	1.51	1.52	1.54	1.55	1.56
r_{yy}		2.31	2.28	2.26	2.23	2.22	2.22
Wt. 2 Ls		54.4	47.2	40.0	32.4	28.6	24.6
Area 2 Ls		15.96	13.88	11.72	9.50	8.36	7.22
Size		5 x 5					
Thickness		7/8	3/4	5/8	1/2	7/16	3/8
AXIS X-X	0	271	236	199	161	142	123
	6	253	221	186	151	133	115
	8	239	209	177	144	127	110
	10	221	193	164	134	118	102
	12	199	175	148	121	107	93
	14	173	153	130	107	95	82
	15	159	140	120	98	87	76
	18	132	117	99	82	72	63
	21	110	98	84	69	61	53
	24	94	82	71	58	51	45
	25		78	67	55	49	42
	26						40
AXIS Y-Y	0	271	236	199	161	142	123
	6	264	229	193	157	138	119
	8	258	224	189	153	135	116
	10	250	217	183	148	131	113
	12	241	209	176	142	125	108
	14	230	199	168	135	119	103
	16	218	188	158	127	112	97
	18	204	176	147	118	104	90
	20	188	161	135	108	95	82
	22	170	146	122	97	85	73
	23	161	138	116	92	81	69
	25	148	128	107	85	75	64
	28	131	114	95	76	66	57
	31	118	101	85	67	59	51
	34	105	90	75	60	53	45
	37	94	80	67	53	47	40
	38	91	78				

Axis	Unsupported length in feet	4 x 4, 3/4	4 x 4, 5/8	4 x 4, 1/2	4 x 4, 7/16	4 x 4, 3/8	4 x 4, 5/16	4 x 4, 1/4
r_{xx}		1.19	1.20	1.22	1.23	1.23	1.24	1.25
r_{yy}		1.88	1.86	1.83	1.82	1.81	1.80	1.79
Wt. 2 Ls		37.0	31.4	25.6	22.6	19.6	16.4	13.2
Area 2 Ls		10.88	9.22	7.50	6.62	5.72	4.80	3.88
Size		4 x 4						
Thickness		3/4	5/8	1/2	7/16	3/8	5/16	1/4
AXIS X-X	0	185	157	127	112	97	82	66
	4	176	150	122	108	93	78	63
	6	166	141	115	102	88	74	60
	8	151	128	105	93	80	68	55
	10	131	112	92	82	71	60	49
	11	120	102	85	75	65	55	45
	12	108	92	77	68	59	50	41
	14	93	79	66	58	51	43	35
	16	81	68	57	50	44	37	30
	18	69	59	49	44	38	32	26
	19	64	55	46	41	35	30	24
	20		51	43	38	33	28	23
AXIS Y-Y	0	185	157	127	112	97	82	66
	6	177	150	122	107	93	78	63
	8	171	145	117	103	89	75	61
	10	163	138	112	98	85	71	58
	12	154	130	105	92	80	67	54
	14	143	120	97	85	73	61	49
	15	136	114	92	81	70	58	47
	16	130	109	87	76	66	55	44
	17	123	103	82	72	62	52	42
	18	115	96	77	67	58	48	39
	20	103	86	69	61	52	43	35
	22	94	78	63	55	47	39	32
	24	85	71	57	50	43	36	29
	26	77	65	52	45	39	32	26
	28	71	59	47	41	35	29	24
	29	67	56	45	39	33	28	22
	30	64	54	43	37	32	27	

Axis	Unsupported length in feet	3½ x 3½, 1/2	3½ x 3½, 7/16	3½ x 3½, 3/8	3½ x 3½, 5/16	3½ x 3½, 1/4
r_{xx}		1.06	1.07	1.07	1.08	1.09
r_{yy}		1.64	1.62	1.61	1.60	1.59
Wt. 2 Ls		22.2	19.6	17.0	14.4	11.6
Area 2 Ls		6.50	5.74	4.96	4.18	3.38
Size		3½ x 3½				
Thickness		1/2	7/16	3/8	5/16	1/4
AXIS X-X	0	110	97	84	71	57
	2	109	96	83	70	57
	4	104	92	79	67	54
	6	96	85	73	62	50
	8	85	75	65	55	45
	10	70	62	54	46	38
	12	58	51	45	38	31
	14	49	43	38	32	26
	16	41	37	32	27	22
	17	38	34	30	25	21
	18				23	19
AXIS Y-Y	0	110	97	84	71	57
	6	104	92	80	67	54
	8	100	88	76	63	51
	10	93	82	71	59	48
	12	86	75	65	54	44
	14	77	67	58	48	39
	15	72	63	54	45	36
	16	67	58	50	42	34
	18	60	52	45	37	30
	20	53	47	40	33	27
	22	48	42	36	30	24
	24	43	37	32	27	21
	26	39	34	29	24	19
	27	37	32			

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.



DOUBLE-ANGLE STRUTS

ALLOWABLE CONCENTRIC LOADS IN KIPS

r_{xx}	.90	.91	.91	.92	.93	.94
r_{yy}	1.43	1.42	1.41	1.40	1.38	1.38
Wt. 2 ⌊s	18.8	16.6	14.4	12.2	9.8	7.4
Area 2 ⌊s	5.50	4.86	4.22	3.56	2.88	2.18
Size	3 x 3					
Thickness	½	7/16	⅜	5/16	¼	3/16
Axis X-X — Unsupported Length in Feet						
0	93	83	72	60	49	37
2	92	81	70	59	48	36
4	86	77	66	56	45	34
5	82	72	63	53	43	33
6	76	68	59	50	41	31
7	70	63	54	46	38	28
8	63	56	49	42	34	26
9	55	49	43	37	30	23
10	50	45	39	33	27	20
12	41	37	32	27	22	17
14	34	30	26	23	18	14
15	31	27	24	21	17	13
Axis Y-Y — Unsupported Length in Feet						
0	93	83	72	60	49	37
2	93	82	71	60	49	37
4	91	80	69	58	47	36
6	87	76	66	56	45	34
8	82	72	62	52	42	32
9	78	69	60	50	40	30
10	75	66	57	48	38	29
11	71	62	54	45	36	27
12	67	58	50	42	34	25
13	62	54	47	39	31	23
14	57	50	43	36	28	21
15	53	46	40	34	27	20
16	50	43	37	32	25	18
18	44	38	33	28	22	16
20	39	34	29	25	19	14
22	34	30	26	22	17	13
23	33	28	24	20	16	

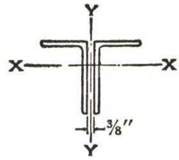
r_{xx}	.74	.75	.76	.77	.78
r_{yy}	1.24	1.21	1.20	1.19	1.18
Wt. 2 ⌊s	15.4	11.8	10.0	8.2	6.1
Area 2 ⌊s	4.50	3.46	2.94	2.38	1.80
Size	2½ x 2½				
Thickness	½	⅜	5/16	¼	3/16
Axis X-X					
0	76	59	50	40	31
2	74	57	49	39	30
3	71	55	47	38	29
4	67	52	44	36	27
5	62	48	41	33	25
6	56	43	37	30	23
7	48	38	33	26	20
8	42	32	28	23	18
9	37	29	25	20	16
10	33	26	22	18	14
11	29	23	20	16	12
12	26	20	18	14	11
13					10
Axis Y-Y					
0	76	59	50	40	31
2	76	58	49	40	30
4	73	56	48	39	29
6	69	53	45	36	27
7	66	51	43	35	26
8	63	48	41	33	25
9	60	45	39	30	23
10	56	42	36	29	22
11	52	39	33	27	20
12	47	35	29	24	18
13	43	32	27	21	16
14	40	30	25	20	15
15	37	28	23	18	14
17	32	24	20	16	12
19	28	21	18	14	10
20	26	20	16		

r_{xx}	.59	.60	.61	.62	.63
r_{yy}	1.02	1.00	.99	.98	.97
Wt. 2 ⌊s	9.4	7.8	6.4	4.9	3.3
Area 2 ⌊s	2.72	2.30	1.88	1.42	.96
Size	2 x 2				
Thickness	⅜	5/16	¼	3/16	⅛
Axis X-X					
0	46	39	32	24	16
2	44	37	31	23	16
3	41	35	29	22	15
4	37	32	26	20	14
5	32	28	23	18	12
6	27	23	19	15	10
7	23	20	16	13	8.7
8	20	17	14	11	7.5
9	17	15	12	10	6.5
10		13	11	8.3	5.7
Axis Y-Y					
0	46	39	32	24	16
2	45	39	31	24	16
4	43	37	30	23	15
5	42	35	29	22	15
6	40	33	27	20	14
7	37	31	25	19	13
8	35	29	23	17	12
9	32	26	21	16	10
10	28	23	19	14	9.3
11	26	21	17	13	8.5
12	23	19	16	12	7.8
13	21	17	14	11	7.1
14	20	16	13	9.7	6.5
15	18	15	12	8.9	5.9
16	16	14	11	8.2	5.4
17	15				

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.

DOUBLE-ANGLE STRUTS

ALLOWABLE CONCENTRIC LOADS IN KIPS

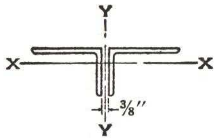


Size	9 x 4					
r_{xx}	2.84	2.86	2.88	2.90	2.91	2.92
r_{yy}	1.55	1.52	1.50	1.47	1.46	1.45
Wt. 2 Ls	81.6	72.2	62.6	52.6	47.6	42.6
Area 2 Ls	24.00	21.22	18.38	15.46	14.00	12.50
Thickness	1	7/8	3/4	5/8	9/16	1/2
Axis X-X — Unsupported length in feet						
0	408	361	312	263	238	213
10	387	342	297	250	227	202
12	378	335	290	244	221	198
14	367	325	282	238	215	192
16	355	314	273	230	208	186
18	341	302	262	221	201	179
20	325	288	251	211	192	172
22	307	273	237	201	182	163
25	278	247	216	183	166	149
28	245	219	191	162	147	132
29	235	209	183	155	141	126
32	214	191	167	141	128	115
35	195	174	152	128	117	105
38	178	159	138	117	107	96
41	162	145	126	107	97	87
44	148	132	115	98	89	90
47	135	121	106	90	82	73
48			103	87	79	71
Axis Y-Y — Unsupported length in feet						
0	408	361	312	263	238	213
6	383	338	292	245	221	198
8	364	320	276	231	209	186
10	338	297	255	213	192	171
12	308	268	230	191	172	153
14	271	235	201	165	148	131
15	251	216	184	152	137	121
18	208	180	154	126	114	101
21	175	151	129	106	95	84
24	148	128	109	89	80	71
25	140	121	103			

Size	8 x 6					
r_{xx}	2.49	2.51	2.53	2.54	2.56	2.57
r_{yy}	2.52	2.50	2.48	2.46	2.44	2.43
Wt. 2 Ls	88.4	78.2	67.6	57.0	46.0	40.4
Area 2 Ls	26.00	22.96	19.88	16.72	13.50	11.86
Thickness	1	7/8	3/4	5/8	1/2	7/16
Axis X-X — Unsupported length in feet						
0	442	390	338	284	230	202
10	413	365	316	266	215	189
12	400	354	307	258	209	184
15	376	333	289	244	197	173
18	347	308	268	226	183	161
21	313	278	242	204	166	146
24	273	244	214	180	147	129
25	259	231	202	171	140	123
26	250	222	194	164	133	117
29	224	200	175	147	120	106
32	202	180	157	133	108	95
35	181	162	141	119	97	86
38	164	146	128	108	88	78
41	148	132	115	97	79	70
42			112	94	77	68
Axis Y-Y — Unsupported length in feet						
0	442	390	338	284	230	202
10	413	365	315	265	214	188
12	401	353	305	256	207	181
15	378	333	287	241	194	170
18	349	307	265	222	178	156
21	316	277	238	199	160	140
24	277	243	208	173	138	121
25	263	230	197	165	132	116
29	227	199	171	142	114	100
33	197	172	148	123	99	86
37	172	150	129	107	86	75
40	156	136	116	96	77	67
41	150	131	112	93		
42	145					

Size	8 x 4					
r_{xx}	2.52	2.53	2.55	2.57	2.59	2.60
r_{yy}	1.61	1.58	1.55	1.53	1.51	1.49
Wt. 2 Ls	74.8	66.2	57.4	48.4	39.2	34.4
Area 2 Ls	22.00	19.46	16.88	14.22	11.50	10.12
Thickness	1	7/8	3/4	5/8	1/2	7/16
Axis X-X — Unsupported length in feet						
0	374	331	287	242	195	172
10	350	310	269	227	184	162
12	339	300	261	220	178	157
14	327	289	251	212	172	152
16	312	276	241	203	165	145
18	296	262	228	193	157	138
20	277	246	214	182	148	130
22	257	228	199	169	138	121
25	223	198	174	148	121	107
26	214	190	166	141	115	101
28	200	177	155	131	107	94
30	186	165	144	122	100	88
32	173	154	134	114	93	82
34	162	143	125	107	87	77
36	151	134	117	99	81	72
39	136	121	106	90	73	65
42	123	109	96	81	67	59
43					64	57
Axis Y-Y — Unsupported length in feet						
0	374	331	287	242	195	172
6	352	311	269	226	183	160
8	336	296	256	214	173	152
10	314	276	238	199	160	140
12	288	252	216	181	145	126
14	258	224	191	158	126	109
15	240	208	177	146	116	101
16	221	192	164	136	109	95
20	177	154	130	108	86	74
24	143	123	104	86	68	59
25	135	117	99	81	65	
26	128	111				

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.



DOUBLE-ANGLE STRUTS

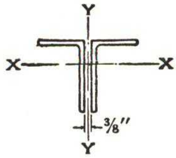
ALLOWABLE CONCENTRIC LOADS IN KIPS

r_{xx}		1.00	1.01	1.02	1.04	1.04	1.05		1.73	1.74	1.76	1.77	1.79	1.80		1.03	1.04	1.05	1.07	1.08	1.09
r_{yy}		4.66	4.63	4.61	4.58	4.56	4.55		3.78	3.76	3.73	3.72	3.69	3.68		4.10	4.07	4.04	4.02	4.00	3.99
Wt. 2 ∟s		81.6	72.2	62.6	52.6	47.6	42.6		88.4	78.2	67.6	57.0	46.0	40.4		74.8	66.2	57.4	48.4	39.2	34.4
Area 2 ∟s		24.00	21.22	18.38	15.46	14.00	12.50		26.00	22.96	19.88	16.72	13.50	11.86		22.00	19.46	16 88	14.22	11.50	10.12
Size		9 x 4							8 x 6							8 x 4					
Thickness		1	7/8	3/4	5/8	9/16	1/2		1	7/8	3/4	5/8	1/2	7/16		1	7/8	3/4	5/8	1/2	7/16
AXIS X-X — UNSUPPORTED LENGTH IN FEET	0	408	361	312	263	238	213	0	442	390	338	284	230	202	0	374	331	287	242	195	172
	4	382	338	293	247	224	200	8	403	356	309	260	211	185	4	351	311	270	228	184	163
	6	348	309	268	227	206	184	12	355	314	273	231	187	165	6	322	286	248	211	171	151
	8	300	268	234	199	181	162	16	287	255	223	189	154	136	8	281	250	219	186	151	134
	10	240	216	189	163	148	134	17	266	238	208	176	145	128	10	229	205	180	155	127	113
	12	200	179	157	135	122	110	18	250	223	195	165	134	119	12	190	170	149	127	104	92
	14	169	151	132	114	103	93	20	226	201	176	149	121	107	14	160	143	125	108	88	79
	16	142	127	111	96	87	79	24	185	164	144	122	100	88	16	135	121	106	91	75	67
	17			103	89	81	73	28	151	135	118	100	82	73	17	125	112	98	84	69	62
								29		128	113	96	78	69	18					64	57
								30						66							
AXIS Y-Y — UNSUPPORTED LENGTH IN FEET	0	408	361	312	263	238	213	0	442	390	338	284	230	202	0	374	331	287	242	195	172
	16	388	343	297	250	226	202	12	424	374	324	272	220	193	12	361	319	277	233	188	166
	20	377	333	289	242	219	196	16	409	361	312	263	212	186	16	351	310	268	226	183	161
	24	364	321	278	233	211	188	20	391	345	298	250	202	177	20	337	298	258	217	175	154
	28	348	306	266	222	201	179	24	369	325	280	236	190	166	24	321	284	245	206	167	146
	32	329	290	250	210	190	169	28	342	301	260	218	175	154	28	302	266	230	194	156	137
	36	308	272	234	196	177	158	32	312	274	236	198	159	139	32	280	247	213	179	144	126
	40	284	250	216	180	163	145	36	277	243	208	175	140	123	36	256	224	193	162	130	114
	44	258	227	195	164	147	131	37	268	235	202	169	135	118	39	236	206	177	148	119	104
	45	252	220	190	159	143	127	40	246	217	186	156	125	110	40	228	200	171	143	115	101
	46	244	214	185	154	139	123	44	224	197	169	142	114	100	44	206	181	156	131	105	92
	48	234	206	177	148	133	118	48	204	179	154	129	103	91	48	189	166	143	119	96	84
	52	216	190	164	137	123	110	52	186	163	140	117	94	82	52	173	152	131	109	88	77
	56	200	176	152	127	114	101	56	170	149	128	107	86	75	56	159	140	120	100	81	71
	60	185	163	140	117	105	94	60	155	136	117	97	78	68	60	146	128	110	92	74	65
	64	172	151	130	109	98	87	61	152	133	114	95	76	67	64	135	118	101	85	68	60
	68	160	140	121	100	91	81	62	148	130	111	93			66	129	113	97	81	65	57
	72	148	130	112	94	84	75	63	145						67	126	110	95	79		
	76	138	121	104	87	78									68	124					
	77	136	119																		

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.

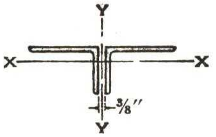
DOUBLE-ANGLE STRUTS

ALLOWABLE CONCENTRIC LOADS IN KIPS



r_{xx}		2.20	2.22	2.24	2.24	2.25	2.26	2.27		1.86	1.88	1.90	1.90	1.91	1.92	1.93		1.92	1.94	1.95
r_{yy}		1.64	1.62	1.59	1.58	1.57	1.55	1.55		1.71	1.69	1.66	1.66	1.65	1.63	1.62		1.40	1.39	1.38
Wt. 2 ∟s		60.4	52.4	44.2	40.0	35.8	31.6	27.2		54.4	47.2	40.0	36.2	32.4	28.6	24.6		30.6	23.4	19.6
Area 2 ∟s		17.72	15.38	12.96	11.74	10.50	9.24	7.96		15.96	13.88	11.72	10.62	9.50	8.36	7.22		9.00	6.84	5.74
Size		7 x 4								6 x 4								6 x 3½		
Thickness		7/8	3/4	5/8	9/16	1/2	7/16	3/8		7/8	3/4	5/8	9/16	1/2	7/16	3/8		1/2	3/8	5/16
AXIS X-X — UNSUPPORTED LENGTH IN FEET	0	301	262	220	200	178	157	135	0	271	236	199	180	161	142	123	0	153	116	98
	8	285	248	209	189	169	149	128	8	251	218	185	168	150	132	114	8	142	108	91
	10	276	240	202	183	164	144	125	10	239	209	177	160	143	126	109	10	136	104	87
	12	264	230	194	176	158	139	120	12	225	196	167	151	135	119	103	12	128	98	82
	14	251	219	185	167	150	132	114	14	208	182	155	141	126	111	96	14	119	91	77
	16	236	206	174	157	141	125	108	16	189	166	141	128	115	102	88	16	109	84	70
	18	218	191	162	146	132	116	100	18	167	147	126	114	103	91	79	18	98	75	63
	20	199	174	148	134	121	107	92	19	157	138	117	107	96	85	74	19	91	70	59
	22	177	156	133	120	108	96	83	20	149	131	112	102	91	81	70	20	87	66	56
	24	163	143	122	110	99	87	76	22	136	119	102	93	83	73	64	22	79	61	51
	26	151	132	112	102	91	81	70	24	123	108	93	84	76	67	58	24	72	55	47
	28	139	122	104	94	84	75	65	26	112	99	85	77	69	61	53	26	66	51	42
	30	128	112	96	87	78	69	60	28	102	90	77	70	63	56	48	28	60	46	39
	33	114	100	85	77	69	61	53	30	93	82	70	64	58	51	44	30	55	42	36
	36	102	89	76	69	62	55	48	31	89	79	67	61	55	49	42	32	50	39	33
	37		86	73	66	60	53	46	32						47	41				
AXIS Y-Y — UNSUPPORTED LENGTH IN FEET	0	301	262	220	200	178	157	135	0	271	236	199	180	161	142	123	0	153	116	98
	6	285	247	207	188	168	148	127	6	258	224	189	171	153	134	116	4	148	112	94
	8	272	235	197	178	159	140	121	8	247	214	180	163	146	128	110	6	141	107	90
	10	255	221	185	167	149	131	112	10	233	202	170	154	137	120	104	8	133	100	84
	12	235	203	169	153	136	119	102	12	216	187	156	141	126	110	95	10	121	91	76
	14	211	181	150	135	120	105	90	14	197	169	141	127	114	99	85	12	107	80	67
	15	198	169	140	125	111	97	83	16	174	149	123	110	99	86	74	13	99	74	62
	16	183	157	129	116	103	89	77	17	161	138	115	104	92	80	69	14	91	68	57
	19	154	132	108	98	87	76	65	18	152	131	109	98	88	76	65	16	79	60	50
	22	131	112	92	83	73	64	55	21	130	112	93	84	74	64	56	18	70	53	44
	25	111	95	78	70	62	54	46	24	112	96	79	71	64	55	47	20	62	46	38
	26	106	91	74	67	59			27	96	82	68	61	54	47	40	22	54	41	34
	27	101	86						28	91	78						23	51	38	32

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.



DOUBLE-ANGLE STRUTS

ALLOWABLE CONCENTRIC LOADS IN KIPS

Size	7 x 4						
r_{xx}	1.07	1.09	1.10	1.11	1.11	1.12	1.13
r_{yy}	3.51	3.49	3.47	3.46	3.45	3.43	3.42
Wt. 2 Ls	60.4	52.4	44.2	40.0	35.8	31.6	27.2
Area 2 Ls	17.72	15.38	12.96	11.74	10.50	9.24	7.96
Thickness	7/8	3/4	5/8	9/16	1/2	7/16	3/8
Axis X-X — Unsupported length in feet							
0	301	262	220	200	178	157	135
4	284	247	208	189	169	149	128
6	262	229	193	175	157	139	120
8	232	204	172	156	140	124	107
10	193	171	146	133	119	106	92
11	173	153	129	119	107	94	82
12	159	141	120	109	97	86	75
14	135	119	101	92	83	74	64
16	115	102	87	79	71	63	55
17	106	94	80	73	65	58	51
18		87	74	68	61	54	47
Axis Y-Y — Unsupported length in feet							
0	301	262	220	200	178	157	135
8	295	256	215	195	175	154	132
12	287	249	209	190	170	149	128
16	276	239	201	182	163	143	123
20	261	226	190	172	154	135	116
24	243	211	177	160	143	126	108
28	222	192	161	146	130	114	98
32	198	171	143	129	115	101	87
34	185	160	133	120	107	94	80
35	178	154	129	116	104	91	78
36	173	150	125	113	101	88	76
40	156	135	113	102	91	80	68
44	141	122	102	92	82	72	62
48	128	110	92	83	74	65	56
52	116	100	84	75	67	58	50
56	105	91	76	68	61	53	45
57	102	88	74	67	59	52	44
58	100	86					

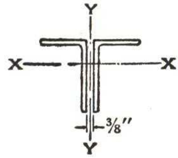
Size	6 x 4						
r_{xx}	1.11	1.12	1.13	1.14	1.15	1.16	1.17
r_{yy}	2.97	2.95	2.92	2.91	2.90	2.88	2.87
Wt. 2 Ls	54.4	47.2	40.0	36.2	32.4	28.6	24.6
Area 2 Ls	15.96	13.88	11.72	10.62	9.50	8.36	7.22
Thickness	7/8	3/4	5/8	9/16	1/2	7/16	3/8
Axis X-X — Unsupported length in feet							
0	271	236	199	180	161	142	123
4	257	224	189	171	153	135	117
6	239	208	176	160	143	127	109
8	213	187	158	144	129	114	99
10	181	159	135	123	111	99	86
11	162	142	121	111	101	90	78
12	148	130	111	101	91	81	70
14	126	111	95	86	78	69	61
16	108	95	81	74	67	60	52
18	92	81	69	64	58	51	45
19				59	54	48	42
Axis Y-Y — Unsupported length in feet							
0	271	236	199	180	161	142	123
8	263	229	193	175	156	138	119
12	253	220	185	168	150	132	114
15	243	211	178	161	144	126	109
18	230	200	168	152	136	119	103
21	216	187	157	142	127	111	96
24	199	172	144	130	116	102	87
27	179	155	130	117	104	91	78
28	172	149	124	112	100	87	75
29	165	143	119	107	95	83	71
30	158	137	115	104	92	81	69
34	140	121	101	91	81	71	61
38	124	107	90	81	72	63	54
42	110	96	80	72	64	56	48
46	98	85	71	64	57	50	42
47	95	82	69	62	55	48	41
48	93	80	67	60	53	47	
49	90	78					

Size	6 x 3½		
r_{xx}	.97	.99	1.00
r_{yy}	2.97	2.95	2.94
Wt. 2 Ls	30.6	23.4	19.6
Area 2 Ls	9.00	6.84	5.74
Thickness	1/2	3/8	5/16
Axis X-X — Unsupported length in feet			
0	153	116	98
4	142	108	91
6	129	99	83
8	110	85	72
9	99	77	65
10	88	68	57
12	73	57	48
14	61	47	40
16	51	40	34
Axis Y-Y — Unsupported length in feet			
0	153	116	98
8	148	113	95
12	143	108	91
14	139	106	88
16	135	103	86
18	130	99	82
20	125	94	79
22	119	90	75
24	112	85	71
26	105	79	66
28	97	73	61
29	93	70	58
30	89	67	56
33	81	61	51
36	74	56	47
39	68	51	43
42	62	47	39
45	57	43	36
48	52	39	33
49	51	38	32

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.

DOUBLE-ANGLE STRUTS

ALLOWABLE CONCENTRIC LOADS IN KIPS



Size 5 x 3½

r_{xx}	1.55	1.56	1.58	1.59	1.60	1.61
r_{yy}	1.54	1.51	1.49	1.47	1.46	1.45
Wt. 2 ∟s	39.6	33.6	27.2	24.0	20.8	17.4
Area 2 ∟s	**11.62**	9.84	8.00	7.06	6.10	5.12
Thickness	¾	⅝	½	7/16	⅜	5/16
Axis X-X — Unsupported length in feet						
0	197	167	136	120	104	87
4	192	163	132	116	101	85
6	185	157	128	113	98	82
8	176	149	122	108	93	78
10	164	139	114	100	87	73
12	149	127	104	92	80	67
14	131	112	92	81	71	60
15	121	104	86	76	66	56
16	113	95	79	70	61	52
18	101	86	71	63	55	46
20	90	76	63	56	49	41
22	80	68	56	50	44	37
24	72	61	51	45	39	33
25	68	58	48	42	37	31
26		55	45	40	35	30
Axis Y-Y — Unsupported length in feet						
0	197	167	136	120	104	87
4	192	162	132	117	101	84
6	185	156	127	112	97	81
8	176	148	120	106	91	76
10	163	137	111	98	84	70
12	148	124	100	88	75	63
14	130	108	87	76	65	54
15	120	99	79	69	60	50
16	112	93	75	66	56	47
18	100	83	66	58	50	41
20	89	74	59	51	44	37
22	79	66	53	45	39	32
24	71	59	47	40	35	29
25	67	55				

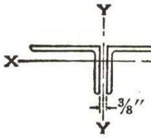
Size 5 x 3

r_{xx}	1.59	1.61	1.61
r_{yy}	1.25	1.23	1.22
Wt. 2 ∟s	25.6	19.6	16.4
Area 2 ∟s	7.50	5.72	4.80
Thickness	½	⅜	5/16
Axis X-X — Unsupported length in feet			
0	128	97	81
2	127	96	81
4	124	95	79
6	120	92	77
8	114	87	73
10	107	81	68
12	97	75	63
14	87	67	56
15	81	62	52
16	75	57	49
18	67	51	43
20	59	46	39
22	53	41	35
24	48	37	31
26	43	33	28
Axis Y-Y — Unsupported length in feet			
0	128	97	81
2	126	96	81
4	122	93	78
6	115	88	73
8	106	80	67
10	94	71	59
12	80	59	49
14	67	50	42
16	58	43	36
18	51	38	31
20	44	33	27

Size 4 x 3½

r_{xx}	1.22	1.23	1.24	1.25	1.26	1.27
r_{yy}	1.60	1.58	1.57	1.56	1.55	1.54
Wt. 2 ∟s	29.4	23.8	21.2	18.2	15.4	12.4
Area 2 ∟s	8.60	7.00	6.18	5.34	4.50	3.62
Thickness	⅝	½	7/16	⅜	5/16	¼
Axis X-X — Unsupported length in feet						
0	146	119	105	91	76	61
2	145	118	104	90	76	61
4	140	114	101	87	73	59
6	132	107	94	82	69	56
8	120	98	87	76	64	52
10	106	87	77	67	57	46
12	88	72	64	56	48	39
14	75	62	56	48	41	33
16	65	54	48	42	35	29
18	56	46	41	36	31	25
20	49	40	36	32	27	22
21					25	20
Axis Y-Y — Unsupported length in feet						
0	146	119	105	91	76	61
2	145	118	104	90	76	61
4	142	116	102	88	74	60
6	138	112	99	85	72	58
8	131	106	93	81	68	55
10	123	99	87	75	63	51
12	112	91	80	69	58	46
14	100	81	71	61	51	41
15	93	75	66	56	47	37
16	86	69	60	52	44	35
18	77	62	54	47	39	31
20	69	55	48	41	35	28
22	62	49	43	37	31	25
24	55	44	39	33	28	22
25	52	42	37	31	26	21
26	50	40	35	30		

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.



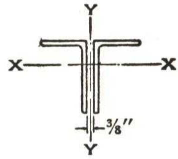
DOUBLE-ANGLE STRUTS

ALLOWABLE CONCENTRIC LOADS IN KIPS

r_{xx}		.98	.99	1.01	1.01	1.02	1.03		.83	.84	.85		1.03	1.04	1.05	1.06	1.07	1.07
r_{yy}		2.48	2.45	2.43	2.41	2.40	2.39		2.50	2.48	2.47		1.91	1.89	1.89	1.88	1.86	1.85
Wt. 2 Ls		39.6	33.6	27.2	24.0	20.8	17.4		25.6	19.6	16.4		29.4	23.8	21.2	18.2	15.4	12.4
Area 2 Ls		**11.62**	9.84	8.00	7.06	6.10	5.12		7.50	5.72	4.80		8.60	7.00	6.18	5.34	4.50	3.62
Size		5 x 3½							5 x 3				4 x 3½					
Thickness		¾	⅝	½	7/16	⅜	5/16		½	⅜	5/16		⅝	½	7/16	⅜	5/16	¼
AXIS X-X, UNSUPPORTED LENGTH IN FEET	0	197	167	136	120	104	87	0	128	97	81	0	146	119	105	91	76	61
	2	194	164	134	118	102	86	2	124	95	80	2	144	117	103	89	75	61
	4	184	156	127	112	97	82	4	115	88	74	4	137	112	99	85	72	58
	6	167	142	116	103	89	75	6	101	77	65	6	126	103	91	79	67	54
	8	143	122	101	89	77	65	8	79	61	52	8	110	90	80	70	59	47
	9	129	110	92	81	70	59	10	62	48	41	10	90	74	66	58	49	39
	10	114	97	81	72	63	53	12	50	39	33	12	74	61	54	47	40	33
	12	96	81	67	60	52	44	13	45	35	30	14	63	52	46	40	34	28
	14	80	68	57	50	44	37	14		32	27	16	53	44	39	34	29	23
	16	67	57	48	42	37	31					17	49	40	36	31	27	22
	17					34	29											
AXIS Y-Y, UNSUPPORTED LENGTH IN FEET	0	197	167	136	120	104	87	0	128	97	81	0	146	119	105	91	76	61
	8	189	160	130	115	99	83	8	122	93	78	4	144	117	103	89	75	60
	10	184	156	127	112	96	81	10	119	91	76	6	140	114	101	87	73	59
	12	179	151	122	108	93	78	12	115	88	73	8	136	110	97	84	71	57
	14	172	145	117	103	89	75	14	111	85	71	10	130	105	93	80	68	54
	16	164	138	112	99	85	71	16	106	81	67	12	122	99	88	76	64	51
	18	155	130	105	93	80	67	18	100	76	64	14	114	92	81	70	59	47
	20	145	121	98	86	74	62	20	94	71	60	16	104	84	74	64	53	43
	22	134	112	90	79	68	57	22	87	66	55	18	93	75	66	57	47	38
	23	128	107	86	75	65	54	23	83	63	53	19	87	70	62	53	44	35
	24	122	101	81	71	61	51	24	79	60	50	20	82	66	59	50	42	33
	26	111	93	75	66	57	47	25	75	57	48	21	79	63	56	48	40	32
	28	103	87	70	61	53	44	26	72	55	46	22	75	61	53	46	38	30
	32	90	75	60	53	46	38	28	68	51	43	24	68	55	48	42	35	28
	36	78	65	52	46	39	33	32	58	44	37	26	62	50	44	38	31	25
	39	70	58	47	41	35	29	36	51	38	32	28	57	46	40	35	29	23
	40	68	56	45	40	34		40	44	33	28	30	52	42	37	32	26	21
	41	66						41	43	32	27	31	50	40	35	30	25	

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.

DOUBLE-ANGLE STRUTS



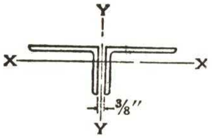
ALLOWABLE CONCENTRIC LOADS IN KIPS

Size	4 x 3					
Thickness	5/8	1/2	7/16	3/8	5/16	1/4
r_{xx}	1.23	1.25	1.25	1.26	1.27	1.28
r_{yy}	1.36	1.33	1.32	1.31	1.30	1.29
Wt. 2 ∟s	27.2	22.2	19.6	17.0	14.4	11.6
Area 2 ∟s	7.96	6.50	5.74	4.96	4.18	3.38
Axis X-X — Unsupported length in feet						
0	135	110	97	84	71	57
2	134	109	96	83	70	57
4	129	106	94	81	68	55
6	122	100	89	76	65	52
8	112	92	82	70	59	48
10	99	81	72	63	53	43
12	82	69	61	53	45	37
14	70	58	52	45	38	31
16	61	51	45	39	33	27
18	53	44	39	34	29	23
20	46	38	34	30	25	21
21					23	19
Axis Y-Y — Unsupported length in feet						
0	135	110	97	84	71	57
2	134	109	96	84	70	57
4	131	106	93	81	68	55
6	125	101	89	77	65	52
8	116	94	82	71	60	48
10	105	85	74	64	54	43
12	92	74	64	55	46	37
13	85	67	59	50	42	33
14	78	62	54	47	39	31
16	68	54	47	41	34	27
18	60	47	41	36	30	24
20	52	42	36	31	26	21
21	49	39	34	29	24	19
22	46	37	32			

Size	3½ x 3				
Thickness	1/2	7/16	3/8	5/16	1/4
r_{xx}	1.07	1.08	1.09	1.10	1.11
r_{yy}	1.38	1.37	1.36	1.35	1.34
Wt. 2 ∟s	20.4	18.2	15.8	13.2	10.8
Area 2 ∟s	6.00	5.30	4.60	3.86	3.12
Axis X-X — Unsupported length in feet					
0	102	90	78	66	53
2	101	89	77	65	52
4	96	85	74	62	50
6	89	78	68	58	47
8	79	70	61	51	42
10	65	58	51	43	35
11	59	52	46	39	32
12	54	47	42	36	29
14	46	41	36	30	25
16	39	34	30	26	21
17	36	32	28	24	19
18		29	26	22	18
Axis Y-Y — Unsupported length in feet					
0	102	90	78	66	53
2	101	89	78	65	53
4	98	86	75	63	51
6	94	83	72	60	49
8	88	77	67	56	45
10	80	70	61	51	41
12	70	61	53	44	36
13	65	57	49	40	32
14	59	52	45	37	30
16	52	45	39	33	26
18	46	40	34	29	23
20	40	35	30	25	20
22	36	31	27	23	18
23	34				

Size	3½ x 2½				
Thickness	1/2	7/16	3/8	5/16	1/4
r_{xx}	1.09	1.09	1.10	1.11	1.12
r_{yy}	1.13	1.12	1.11	1.10	1.09
Wt. 2 ∟s	18.8	16.6	14.4	12.2	9.8
Area 2 ∟s	5.50	4.86	4.22	3.56	2.88
Axis X-X — Unsupported length in feet					
0	93	83	72	61	49
2	92	82	71	60	48
4	88	78	68	57	46
6	82	73	63	53	43
8	73	65	56	48	39
10	61	54	47	40	33
11	54	48	42	36	29
12	50	45	39	33	27
14	43	38	33	28	23
16	36	32	28	24	20
17	33	30	26	22	18
18	31	28	24	21	17
Axis Y-Y — Unsupported length in feet					
0	93	83	72	61	49
2	92	81	71	60	48
4	89	78	68	57	46
6	83	73	63	53	43
8	74	65	56	47	38
10	63	55	48	40	32
11	57	50	43	36	29
12	52	45	39	33	26
14	44	38	33	28	22
16	38	33	29	24	19
18	33	28	24	20	16

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.



DOUBLE-ANGLE STRUTS

ALLOWABLE CONCENTRIC LOADS IN KIPS

		4 x 3					
r_{xx}		.85	.86	.87	.88	.89	.90
r_{yy}		1.99	1.96	1.95	1.94	1.93	1.92
Wt. 2 ∟s		27.2	22.2	19.6	17.0	14.4	11.6
Area 2 ∟s		7.96	6.50	5.74	4.96	4.18	3.38
Thickness		5/8	1/2	7/16	3/8	5/16	1/4
Axis X-X, Unsupported Length in Feet	0	135	110	97	84	71	57
	2	132	108	96	83	70	56
	4	123	101	89	77	65	53
	6	108	88	78	68	58	47
	8	86	71	64	56	47	39
	9	75	62	56	49	41	34
	10	68	56	50	44	37	31
	12	55	46	41	36	31	25
	14	45	37	34	30	25	21
	15						19
Axis Y-Y, Unsupported Length in Feet	0	135	110	97	84	71	57
	4	133	109	96	83	70	56
	6	130	106	93	81	68	55
	8	126	103	90	78	66	53
	10	121	99	87	75	63	51
	12	115	93	82	71	60	48
	14	107	87	76	66	56	45
	16	99	80	70	61	51	41
	18	90	72	63	54	46	37
	19	84	68	59	51	43	35
	20	79	64	56	48	40	33
	22	72	58	51	44	37	30
	24	66	53	47	40	34	27
	26	61	49	43	37	31	25
	28	56	44	39	34	28	23
	30	51	41	36	31	26	21
	32	47	37	33	28	23	19
	33	45					

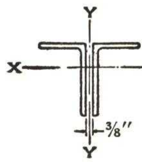
		3½ x 3				
r_{xx}		.88	.89	.90	.90	.91
r_{yy}		1.70	1.68	1.67	1.66	1.65
Wt. 2 ∟s		20.4	18.2	15.8	13.2	10.8
Area 2 ∟s		6.00	5.30	4.60	3.86	3.12
Thickness		1/2	7/16	3/8	5/16	1/4
Axis X-X	0	102	90	78	66	53
	2	100	89	77	64	52
	4	93	83	72	60	49
	6	83	74	64	54	44
	8	67	60	53	44	36
	9	59	52	46	39	32
	10	53	47	42	35	29
	12	43	39	34	29	23
	14	36	32	28	24	19
	15			26	22	17
Axis Y-Y	0	102	90	78	66	53
	4	100	88	76	64	52
	6	97	86	74	62	50
	8	93	82	71	59	48
	10	87	77	67	56	45
	12	81	72	62	52	42
	14	74	65	56	46	37
	16	65	57	49	41	33
	17	60	52	45	38	30
	18	57	50	42	35	28
	20	51	45	39	32	25
	22	46	40	35	28	23
	24	42	36	31	25	20
	26	38	33	28	23	18
	27	36	31	26		

		3½ x 2½				
r_{xx}		.70	.71	.72	.73	.74
r_{yy}		1.76	1.75	1.74	1.73	1.71
Wt. 2 ∟s		18.8	16.6	14.4	12.2	9.8
Area 2 ∟s		5.50	4.86	4.22	3.56	2.88
Thickness		1/2	7/16	3/8	5/16	1/4
Axis X-X	0	93	82	72	60	49
	2	90	80	69	59	47
	4	81	72	63	53	43
	6	65	58	51	44	36
	7	55	50	44	38	31
	8	48	43	38	33	27
	10	38	34	30	26	21
	11	33	30	26	23	19
	12			23	20	17
Axis Y-Y	0	93	82	72	60	49
	4	92	81	70	59	48
	6	89	78	68	58	46
	8	86	76	66	55	45
	10	81	71	62	52	42
	12	76	67	58	49	39
	14	69	61	53	44	35
	16	62	54	47	39	31
	17	58	51	44	37	29
	18	54	47	41	34	27
	20	49	43	37	30	24
	22	44	39	34	27	22
	24	40	35	30	25	20
	26	36	32	27	22	18
	27	34	30	26	21	17
	28	33	28	24	20	

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.

DOUBLE-ANGLE STRUTS

ALLOWABLE CONCENTRIC LOADS IN KIPS



Size 3 x 2½

	1/2	7/16	3/8	5/16	1/4
r_{xx}	.91	.92	.93	.94	.95
r_{yy}	1.18	1.17	1.16	1.14	1.13
Wt. 2 Ls	17.0	15.2	13.2	11.2	9.0
Area 2 Ls	5.00	4.42	3.84	3.24	2.62
Axis X-X — Unsupported length in feet					
0	85	75	65	55	45
2	83	74	64	54	44
4	78	69	60	51	41
5	74	66	57	49	39
6	70	62	54	46	37
7	64	57	50	43	35
8	58	52	45	39	32
9	51	46	40	34	28
10	46	41	36	31	25
11	41	37	33	28	23
12	38	34	30	25	20
14	31	28	25	21	17
15	28	25	22	19	16
Axis Y-Y — Unsupported length in feet					
0	85	75	65	55	45
2	84	74	64	54	44
4	81	72	62	52	42
5	79	70	60	51	41
6	76	67	58	49	39
7	73	64	56	47	38
8	69	61	53	44	36
9	65	57	49	41	33
10	60	53	45	38	31
11	54	48	41	34	27
12	49	44	37	31	25
13	46	40	34	29	23
14	42	37	32	26	21
16	36	32	27	23	18
18	31	28	24	19	16
19	29	26	22	18	

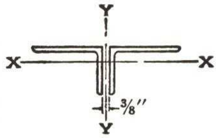
Size 3 x 2

	1/2	7/16	3/8	5/16	1/4	3/16
r_{xx}	.92	.93	.94	.95	.96	.97
r_{yy}	.94	.93	.92	.90	.89	.88
Wt. 2 Ls	15.4	13.6	11.8	10.0	8.2	6.1
Area 2 Ls	4.50	4.00	3.46	2.94	2.38	1.80
Axis X-X — Unsupported length in feet						
0	76	68	59	50	41	30
2	75	67	58	49	40	30
3	73	65	56	48	39	29
4	71	63	54	46	38	28
5	67	60	52	44	36	27
6	63	56	49	42	34	26
7	58	52	45	39	32	24
8	53	47	41	35	29	22
9	46	42	37	32	26	20
10	42	38	33	28	23	18
11	38	34	30	25	21	16
12	34	31	27	23	19	15
15	26	23	20	18	14	11
16					13	10
Axis Y-Y — Unsupported length in feet						
0	76	68	59	50	41	30
2	75	67	58	49	40	30
3	73	65	56	48	39	29
4	71	63	54	46	37	28
5	68	60	52	44	35	27
6	64	56	49	41	33	25
7	59	52	45	38	30	23
8	54	47	41	34	27	20
9	48	42	36	30	24	18
10	43	38	32	27	21	16
11	39	34	29	24	19	14
12	36	31	26	22	17	13
13	32	28	24	20	16	12
14	30	25	22	18	14	11
15	27	23	20	16		

Size 2½ x 2

	3/8	5/16	1/4	3/16
r_{xx}	.77	.78	.78	.79
r_{yy}	.96	.95	.94	.92
Wt. 2 Ls	10.6	9.0	7.2	5.5
Area 2 Ls	3.10	2.62	2.12	1.62
Axis X-X — Unsupported length in feet				
0	52	44	36	28
2	51	43	35	27
3	49	42	34	26
4	47	40	32	25
5	44	37	30	23
6	40	34	27	21
7	35	30	24	19
8	30	26	21	16
9	27	23	19	14
10	24	20	17	12
11	21	18	15	11
12	19	16	13	10
13		15	12	9
Axis Y-Y — Unsupported length in feet				
0	52	44	36	28
2	52	44	35	27
3	51	43	35	26
4	49	41	33	25
5	47	39	32	24
6	44	37	30	23
7	41	35	28	21
8	38	32	25	19
9	34	28	22	17
10	30	25	20	15
11	27	23	18	14
12	25	21	16	12
13	23	19	15	11
14	21	17	14	10
15	19	16	13	9
16	17			

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.



DOUBLE-ANGLE STRUTS

ALLOWABLE CONCENTRIC LOADS IN KIPS

Size 3 x 2½

		1/2	7/16	3/8	5/16	1/4
r_{xx}		.72	.73	.74	.74	.75
r_{yy}		1.50	1.49	1.48	1.46	1.45
Wt. 2 ∟s		17.0	15.2	13.2	11.2	9.0
Area 2 ∟s		5.00	4.42	3.84	3.24	2.62
Axis X-X	0	85	75	65	55	45
	2	82	73	63	53	43
	3	79	70	61	51	42
	4	74	66	58	48	39
	5	68	61	53	45	36
	6	61	55	48	40	33
	7	52	47	41	35	29
	8	45	40	36	30	25
	10	35	32	28	24	19
	12	28	25	22	19	15
Axis Y-Y	0	85	75	65	55	45
	2	85	75	65	55	44
	4	83	73	63	53	43
	6	79	70	61	51	41
	8	75	66	57	48	39
	10	69	61	53	44	36
	11	66	59	51	42	34
	12	63	56	48	40	32
	13	59	52	45	37	30
	14	55	48	41	34	27
	15	50	44	38	32	25
	16	47	41	36	30	24
	17	44	39	34	28	22
	18	42	37	31	26	21
	20	37	32	28	23	19
	22	33	29	25	21	17
	24	30	26	22	18	15
	25	28				

Size 3 x 2

		1/2	7/16	3/8	5/16	1/4	3/16
r_{xx}		.55	.55	.56	.57	.57	.58
r_{yy}		1.57	1.56	1.54	1.53	1.52	1.51
Wt. 2 ∟s		15.4	13.6	11.8	10.0	8.2	6.1
Area 2 ∟s		4.50	4.00	3.46	2.94	2.38	1.80
Axis X-X	0	76	68	59	50	41	30
	2	72	64	56	47	38	29
	3	67	60	52	44	36	27
	4	60	53	46	40	32	24
	5	51	46	40	34	28	21
	6	42	37	32	28	22	17
	7	35	31	28	24	19	15
	8	30	27	24	20	17	13
	9	26	23	20	18	14	11
Axis Y-Y	0	76	68	59	50	41	30
	2	76	67	58	50	40	30
	4	74	66	57	49	39	30
	6	72	63	55	47	38	29
	8	68	60	52	44	36	27
	10	64	56	49	41	33	25
	11	61	54	47	39	32	24
	12	58	51	44	37	30	23
	13	55	48	42	35	28	21
	14	52	45	39	33	26	20
	15	48	42	36	31	24	18
	16	44	39	33	28	23	17
	17	42	37	31	27	21	16
	18	40	35	30	25	20	15
	20	35	31	27	22	18	13
	22	32	28	24	20	16	12
	24	28	25	21	18	14	11
	25	27	23	20	17	13	10
	26	25	22				

Size 2½ x 2

		3/8	5/16	1/4	3/16
r_{xx}		.58	.58	.59	.60
r_{yy}		1.27	1.26	1.25	1.24
Wt. 2 ∟s		10.6	9.0	7.2	5.5
Area 2 ∟s		3.10	2.62	2.12	1.62
Axis X-X	0	53	44	36	28
	2	50	42	34	26
	3	47	40	32	25
	4	42	36	29	23
	5	37	31	25	20
	6	30	26	21	16
	7	26	22	18	14
	8	22	19	15	12
	9	19	16	13	10
	10				9
Axis Y-Y	0	53	44	36	28
	2	52	44	36	27
	4	50	43	35	26
	6	48	40	33	25
	7	46	39	31	24
	8	44	37	30	23
	9	42	35	29	22
	10	39	33	27	20
	11	36	31	25	19
	12	33	28	22	17
	13	30	25	20	15
	14	28	24	19	14
	15	26	22	18	13
	16	25	21	16	13
	17	23	19	15	12
	18	21	18	14	11
	19	20	17	13	10
	20	19	16	13	9
	21	18	15		

UNSUPPORTED LENGTH IN FEET

Loads below horizontal dashed lines are for l/r greater than 120, and apply only to bracing and secondary members. For main members they must be reduced (A. I. S. C. Spec. Sect. 16 (b)); see Example 2 on page 210.

COLUMNS

STEEL PIPE

ALLOWABLE CONCENTRIC LOADS IN KIPS

For Dimensions and Designing Properties of Pipe see Page 139.

STANDARD

Unbraced Length Feet	Nominal Diameter—Weight per Foot											
	12		10			8		6	5	4	3½	3
	49.56	43.77	40.48	34.24	31.20	28.55	24.70	18.97	14.62	10.79	9.11	7.58
6	246	217	200	169	154	140	121	92	70	50	42	33
8	244	216	199	168	153	138	120	90	68	47	38	30
10	243	214	196	166	151	136	118	86	64	44	35	26
12	240	212	194	164	149	133	115	82	61	40	30	21
14	237	210	190	161	147	129	112	79	56	34	25	18
16	234	207	187	158	144	125	109	74	51	30	22	16
18	231	204	182	154	141	121	105	69	45	26	19	13
20	227	200	178	151	137	115	100	63	41	23	17	
22	222	196	172	146	133	109	95	56	37	21	15	

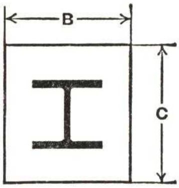
EXTRA STRONG

Unbraced Length Feet	Nominal Diameter—Weight per Foot							
	12	10	8	6	5	4	3½	3
	65.42	54.74	43.39	28.57	20.78	14.98	12.51	10.25
6	325	271	213	139	99	70	58	45
8	323	268	210	135	96	65	53	40
10	320	265	206	131	91	60	47	35
12	317	261	201	125	85	54	40	28
14	313	257	196	119	79	47	34	24
16	309	252	189	112	71	40	30	21
18	304	246	182	103	63	36	26	18
20	299	239	173	94	56	32	23	
22	293	232	164	84	51	28		
24	286	224	155	77	46	25		

DOUBLE EXTRA STRONG

Unbraced Length Feet	Nominal Diameter—Weight per Foot					
	8	6	5	4	3½	3
	72.42	53.16	38.55	27.54	22.85	18.58
6	355	257	183	130	103	80
8	350	249	176	118	93	70
10	343	240	165	108	82	59
12	334	228	154	94	68	48
14	324	213	140	79	58	40
16	312	200	125	70	50	34
18	299	182	109	61	43	
20	284	163	98	54	38	
22	269	147	88	47		
24	250	135	80			
26	230	124	72			

Loads below heavy line are for secondary members with l/r ratios between 120 and 200. For main members of same length, reduce as shown on Page 210. Properties of steel from which pipe is made are assumed to be those of A.S.T.M. A7. If pipe is made of other steel, safe loads should be suitably modified.



COLUMN BASE PLATES

DIMENSIONS FOR MAXIMUM COLUMN LOADS

ALLOWABLE BENDING STRESS 20000 POUNDS PER SQUARE INCH

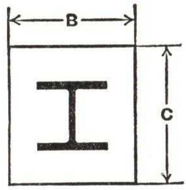
Column				Maxi-mum Column Load	Unit Pressure on Support 600 Pounds per Sq. In.						Unit Pressure on Support 800 Pounds per Sq. In.					
Nominal Size	Weight per Foot	Depth of Column	Width of Flange		Thickness of Plate			Dimen-sions		Gross Wt.	Thickness of Plate			Dimen-sions		Gross Wt.
					Calc.	Fin.	Rol'd	B	C		Calc.	Fin.	Rol'd	B	C	
In.	Lb.	In.	In.	Kips	In.	In.	In.	In.	In.	Lb.	In.	In.	In.	In.	In.	Lb.
14 x 16	426	18.69	16.695	2113	6.83	7	7½	59	60	7522	6.51	6⅝	7	51	52	5259
	398	18.31	16.590	1973	6.40	6⅝	7	56	59	6552	5.98	6⅛	6½	48	52	4596
	370	17.94	16.475	1834	6.25	6⅝	7	55	56	6108	6.02	6⅛	6½	48	48	4243
	342	17.56	16.365	1696	5.80	6⅛	6½	52	55	5267	5.43	5¾	6	44	48	3590
	314	17.19	16.235	1556	5.55	5¾	6	50	52	4419	5.39	5¾	6	44	44	3291
	287	16.81	16.130	1422	5.23	5¼	5½	48	50	3740	4.83	5¼	5½	41	44	2811
	264	16.50	16.025	1308	4.95	5¼	5½	46	48	3440	4.70	4¾	5	40	41	2323
	246	16.25	15.945	1219	4.70	4¾	5	44	46	2867	4.38	4¾	5	38	40	2153
	237	16.12	15.910	1174	4.67	4¾	5	44	45	2805	4.26	4¼	4½	37	40	1887
	228	16.00	15.865	1130	4.54	4¾	5	43	44	2680	4.14	4¼	4½	36	39	1790
	219	15.87	15.825	1084	4.34	4¾	5	41	44	2555	4.02	4¼	4½	36	38	1550
	211	15.75	15.800	1046	4.34	4¾	5	40	44	2493	4.01	4	4	36	37	1509
	202	15.63	15.750	1001	4.10	4¼	4½	40	42	2142	3.87	4	4	35	36	1428
	193	15.50	15.710	956	4.11	4¼	4½	40	40	2040	3.70	4	4	33	36	1346
	184	15.38	15.660	911	3.82	4¼	4½	38	40	1938	3.69	4	4	32	36	1305
	176	15.25	15.640	871	3.95	4	4	36	41	1673	3.38	3½	3½	32	34	1079
	167	15.12	15.600	827	3.66	4	4	36	39	1591	3.35	3½	3½	32	33	1047
	158	15.00	15.550	783	3.50	4	4	36	37	1509	3.19	3½	3½	31	32	984
	150	14.88	15.515	742	3.36	4	4	35	36	1428	3.09	3½	3½	29	32	920
	142	14.75	15.500	705	3.28	4	4	33	36	1346	3.09	3½	3½	28	32	888

Plates 4 inches thick, or under, may be flattened by pressing. For plates more than 4 inches thick, rolled thickness includes allowance for planing top surface. Additional allowance must be made for finishing bottom surface of base plates to be set on grillages. Structural drawings should show finished thickness. Mill orders should specify rolled thickness.

Above base plate sizes computed by method given on page 129.

COLUMN BASE PLATES

DIMENSIONS FOR MAXIMUM COLUMN LOADS

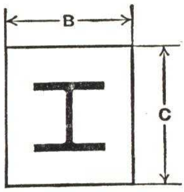


ALLOWABLE BENDING STRESS 20000 POUNDS PER SQUARE INCH

Column				Maximum Column Load	Unit Pressure on Support 600 Pounds per Sq. In.						Unit Pressure on Support 800 Pounds per Sq. In.					
Nominal Size	Weight per Foot	Depth of Column	Width of Flange		Thickness of Plate			Dimensions		Gross Wt.	Thickness of Plate			Dimensions		Gross Wt.
					Calc.	Fin.	Rol'd	B	C		Calc.	Fin.	Rol'd	B	C	
In.	Lb.	In.	In.	Kips	In.	In.	In.	In.	In.	Lb.	In.	In.	In.	In.	In.	Lb.
14 x 14½	136	14.75	14.740	673	3.15	3½	3½	32	35	1111	2.81	3	3	28	30	714
	127	14.62	14.690	628	3.03	3½	3½	32	33	1047	2.82	3	3	28	28	666
	119	14.50	14.650	589	2.88	3½	3½	31	32	984	2.61	3	3	27	28	643
	111	14.37	14.620	549	2.89	3	3	28	33	785	2.46	3	3	25	28	595
	103	14.25	14.575	509	2.59	3	3	28	31	738	2.31	2½	2½	24	27	459
	95	14.12	14.545	470	2.45	3	3	28	28	666	2.12	2½	2½	24	25	425
	87	14.00	14.500	430	2.19	3	3	26	28	619	1.95	2	2	23	24	313
14 x 12	84	14.18	12.023	413	2.32	2½	2½	24	29	493	2.12	2½	2½	22	24	374
	78	14.06	12.000	384	2.15	2½	2½	24	27	459	1.84	2	2	20	24	272
14 x 10	74	14.19	10.072	361	2.40	2½	2½	24	25	425	1.88	2	2	19	24	258
	68	14.06	10.040	332	2.25	2½	2½	23	24	391	1.81	2	2	18	24	245
	61	13.91	10.000	297	1.93	2	2	21	24	286	1.84	2	2	16	24	218
14 x 8	53	13.94	8.062	254	1.72	2	2	18	24	245	1.65	2	2	16	20	181
	48	13.81	8.031	230	1.63	2	2	16	24	218	1.46	2	2	15	20	170
	43	13.68	8.000	206	1.42	1½	1½	16	22	150	1.21	2	2	13	20	147
12 x 12	190	14.38	12.670	936	4.33	4¾	5	39	40	2210	3.93	4	4	33	36	1346
	161	13.88	12.515	794	3.89	4	4	36	37	1509	3.64	4	4	31	32	1124
	133	13.38	12.365	655	3.32	3½	3½	32	34	1079	3.15	3½	3½	28	29	805
	120	13.12	12.320	591	3.16	3½	3½	31	32	984	2.93	3	3	27	28	643
	106	12.88	12.230	522	2.82	3	3	28	31	738	2.57	3	3	24	27	551
	99	12.75	12.190	487	2.74	3	3	28	29	690	2.44	2½	2½	24	26	442
	92	12.62	12.155	453	2.59	3	3	27	28	643	2.45	2½	2½	24	24	408
	85	12.50	12.105	418	2.41	3	3	25	28	595	2.12	2½	2½	22	24	374
	79	12.38	12.080	388	2.28	2½	2½	24	27	459	2.08	2½	2½	21	24	357
	72	12.25	12.040	354	2.14	2½	2½	24	25	425	1.80	2	2	20	22	249
	65	12.12	12.000	320	1.88	2	2	22	24	299	1.80	2	2	20	20	227

Plates 4 inches thick, or under, may be flattened by pressing. For plates more than 4 inches thick, rolled thickness includes allowance for planing top surface. Additional allowance must be made for finishing bottom surface of base plates to be set on grillages. Structural drawings should show finished thickness. Mill orders should specify rolled thickness.

Above base plate sizes computed by method given on page 129.



COLUMN BASE PLATES

DIMENSIONS FOR MAXIMUM COLUMN LOADS

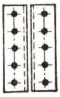
ALLOWABLE BENDING STRESS 20000 POUNDS PER SQUARE INCH

Column				Maximum Column Load	Unit Pressure on Support 600 Pounds per Sq. In.						Unit Pressure on Support 800 Pounds per Sq. In.					
Nominal Size	Weight per Foot	Depth of Column	Width of Flange		Thickness of Plate			Dimensions		Gross Wt.	Thickness of Plate			Dimensions		Gross Wt.
					Calc.	Fin.	Rol'd	B	C		Calc.	Fin.	Rol'd	B	C	
In.	Lb.	In.	In.	Kips	In.	In.	In.	In.	In.	Lb.	In.	In.	In.	In.	In.	Lb.
12 x 10	58	12.19	10.014	283	1.85	2	2	20	24	272	1.72	2	2	18	20	204
	53	12.06	10.000	258	1.88	2	2	18	24	245	1.52	2	2	17	20	193
12 x 8	50	12.19	8.077	240	1.84	2	2	17	24	231	1.48	2	2	15	20	170
	45	12.06	8.042	216	1.71	2	2	16	23	209	1.45	1½	1½	14	20	119
	40	11.94	8.000	192	1.44	1½	1½	16	20	136	1.28	1½	1½	14	18	107
10 x 10	112	11.38	10.415	548	3.15	3½	3½	29	32	920	2.95	3	3	25	28	595
	100	11.12	10.345	490	2.97	3	3	28	29	690	2.70	3	3	24	26	530
	89	10.88	10.275	436	2.66	3	3	26	28	619	2.54	3	3	23	24	469
	77	10.62	10.195	377	2.40	2½	2½	24	26	442	2.39	2½	2½	20	24	340
	72	10.50	10.170	352	2.50	2½	2½	25	24	425	2.08	2½	2½	20	22	312
	66	10.38	10.117	323	2.21	2½	2½	23	24	391	2.02	2½	2½	20	21	297
	60	10.25	10.075	294	2.11	2½	2½	21	24	357	1.87	2	2	19	20	215
	54	10.12	10.028	264	1.86	2	2	20	22	249	1.77	2	2	17	20	193
	49	10.00	10.000	239	1.79	2	2	20	20	227	1.63	2	2	16	19	172
10 x 8	45	10.12	8.022	217	1.74	2	2	18	20	204	1.66	2	2	16	17	154
	39	9.94	7.990	188	1.57	2	2	16	20	181	1.31	1½	1½	14	17	101
	33	9.75	7.964	159	1.43	1½	1½	16	17	116	1.14	1½	1½	13	16	88
8 x 8	67	9.00	8.287	324	2.43	2½	2½	23	24	391	2.28	2½	2½	20	21	297
	58	8.75	8.222	280	2.32	2½	2½	20	24	340	2.00	2	2	18	20	204
	48	8.50	8.117	232	2.00	2	2	20	20	227	1.72	2	2	16	18	163
	40	8.25	8.077	193	1.83	2	2	16	20	181	1.48	1½	1½	15	16	102
	35	8.12	8.027	169	1.53	2	2	16	18	163	1.40	1½	1½	14	16	95
	31	8.00	8.000	149	1.42	1½	1½	16	16	109	1.28	1½	1½	14	14	83
8 x 6½	28	8.06	6.540	132	1.30	1½	1½	14	16	95	1.16	1½	1½	12	14	71
	24	7.93	6.500	113	1.29	1½	1½	14	14	83	1.08	1½	1½	12	14	71

Plates 4 inches thick, or under, may be flattened by pressing. For plates more than 4 inches thick, rolled thickness includes allowance for planing top surface. Additional allowance must be made for finishing bottom surface of base plates to be set on grillages. Structural drawings should show finished thickness. Mill orders should specify rolled thickness.

Above base plate sizes computed by method given on page 129.

RIVETS 7/8" HOLES 15/16"



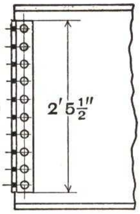
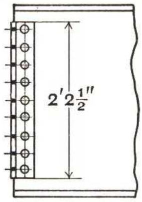
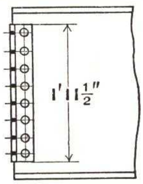
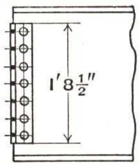
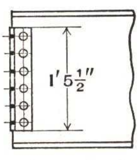
STANDARD BEAM CONNECTIONS

"A" SERIES

ALLOWABLE LOADS IN KIPS

A

These "A" Series Connections are "A.I.S.C. Standard" for the respective beams, and should in general be used for reactions not greater than those herein tabulated. For greater reactions use "HH" Connection, page 254, or design special connections according to the general principles on page 260. For beams framing opposite, see Note and Formula, page 254.

Connection	Rivets in Outstanding Legs		Rivets in Web Legs		Maximum Value	
	No.	Shear	Bearing	Shear	Section	R
A 10  2Ls $4 \times 3\frac{1}{2} \times \frac{7}{16}$	20	180.4	350 t t=thickness of web	180.4	36 WF (all weights)	180.4
A 9  2Ls $4 \times 3\frac{1}{2} \times \frac{7}{16}$	18	162.4	315 t	162.4	33 WF (all weights)	162.4
A 8  2Ls $4 \times 3\frac{1}{2} \times \frac{7}{16}$	16	144.3	280 t	144.3	30 WF (all weights)	144.3
A 7  2Ls $4 \times 3\frac{1}{2} \times \frac{7}{16}$	14	126.3	245 t	126.3	27 WF 177 to 102 94	126.3 120.0†
A 6  2Ls $4 \times 3\frac{1}{2} \times \frac{7}{16}$	12	108.2	210 t	108.2	24 WF 160 to 120 110 100 94 84 76 24 I 120 to 90 79.9	108.2 107.1† 98.3† 108.2 98.6† 92.4† 108.2 105.0†

†The values tabulated for these connections have been reduced to those permitted by web bearing.

See pages 150 and 151 for weights of Standard Connections and minimum spans to which applicable.

HOLES $\frac{15}{16}''$ RIVETS $\frac{7}{8}''$

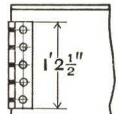
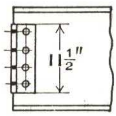
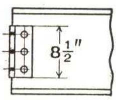
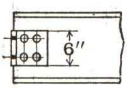
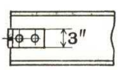
STANDARD BEAM CONNECTIONS

"A" SERIES

ALLOWABLE LOADS IN KIPS

A

These "A" Series Connections are "A.I.S.C. Standard" for the respective beams, and should in general be used for reactions not greater than those herein tabulated. For greater reactions use "H" or "HH" Connections, page 255, or design special connections according to the general principles on page 260. For beams framing opposite, see Note and Formula, page 254.

	Rivets in Out-standing Legs		Rivets in Web Legs		Maximum Value			
	No.	Shear	Bearing	Shear	Section	R	Section	R
A 5  2Ls 4 x 3½ x 7/16					21WF 142 to 96	90.2	20 I 95 to 75	90.2
			175 t		82	87.3†	65.4	87.5†
	10	90.2	t = thick-	90.2	73	79.6†		
			ness		68	75.3†		
			of web		62	70.0†		
A 4  2Ls 4 x 3½ x 3/8					18WF 114 to 105	72.2	16 WF 71	68.0†
					96	71.7†	64	62.0†
					85	72.2	58	57.0†
					77	66.5†	50	53.2†
					70	61.3†	45	48.4†
					64	56.4†	40	43.0†
					60	58.3†	36	41.9†
					55	54.6†		
					50	50.1†	18 I 70	72.2
	8	72.2	140 t	72.2			54.7	64.4†
					16WF 96	72.2	15 I 50	72.2
					88	70.6†		
					78	72.2		
							42.9	57.4†
A 3  2Ls 4 x 3½ x 3/8					14WF 38	32.9†	12 I 50	54.1
					34	30.2†	40.8	48.3†
					30	28.4†	35	44.9†
							31.8	36.8†
	6	54.1	105 t	54.1	12WF 36	32.0†		
					31	27.8†		
					27	25.2†		
A 2  2Ls 6 x 4 x 3/8					10WF 29	36.1	10 I (35 and 25.4)	36.1
					25	33.0†	8 I 23.0	36.1
	4	36.1	140 t	72.2*	21	30.9†	18.4	28.1†
					8WF 20	26.2†		
					17	23.9†		
A 1  2Ls 6 x 4 x 3/8					7 I 20	18.0	5 I 14.75	18.0
					15.3	17.5†	10	13.7†
	2	18.0	70 t	36.1*				
					6 I 17.25	18.0		
					12.5	16.1†		

*These values are theoretical. They cannot be attained by webs of any of the listed beams.

†The values tabulated for these connections have been reduced to those permitted by web bearing or web shear, whichever governs.

See pages 150 and 151 for weights of Standard Connections and minimum spans to which applicable.

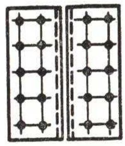
RIVETS $\frac{7}{8}''$ HOLES $\frac{15}{16}''$

STANDARD BEAM CONNECTIONS

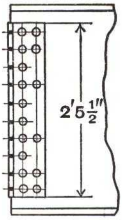
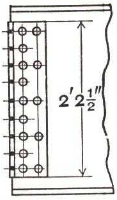
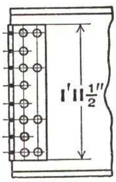
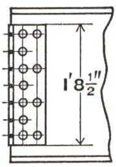
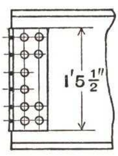
"H" & "HH" SERIES

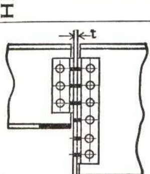
ALLOWABLE LOADS IN KIPS

H



HH

Connection		Rivets in Outstanding Legs				Rivets in Web Legs		Maximum Value		
		H		HH						
		No.	Shear	No.	Shear	Bearing	Shear	Section	H	HH
H 10-2L^s 6×4×$\frac{7}{16}$ HH 10-2L^s 6×6×$\frac{7}{16}$				40	360.8	560 t t=thick-ness of web	288.6	36 WF (all weights)		288.6
H 9-2L^s 6×4×$\frac{7}{16}$ HH 9-2L^s 6×6×$\frac{7}{16}$				36	324.7	490 t	252.6	33 WF 240 to 141 130		252.6 249.6†
H 8-2L^s 6×4×$\frac{7}{16}$ HH 8-2L^s 6×6×$\frac{7}{16}$				32	288.6	420 t	216.5	30 WF 210 to 116 108		216.5 212.4†
H 7-2L^s 6×4×$\frac{7}{16}$ HH 7-2L^s 6×6×$\frac{7}{16}$				28	252.6	385 t	198.4	27 WF 177 to 114 102 94		198.4 182.3† 171.4†
H 6-2L^s 6×4×$\frac{7}{16}$ HH 6-2L^s 6×6×$\frac{7}{16}$				24	216.5	350 t	180.4	24 WF 160 and 145 130 120 110 100 94 84 76		180.4 178.1† 175.7† 160.2† 146.0† 162.9† 147.2† 136.8†



Note for all Connections;

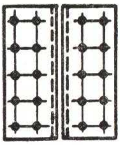
Where some of the rivets in outstanding legs frame opposite, through a plate less than $\frac{1}{2}''$ thick, reduce above values for outstanding legs by 1.09 nk, where n—number of rivets framing opposite and k—number of sixteenths by which t is less than $\frac{1}{2}''$. Note that value of rivets in web legs may still control. Above formula for $\frac{7}{8}''$ rivets only.

†The values tabulated for these connections have been reduced to those permitted by web bearing or web shear, whichever governs.

Values for "H" Connections have been omitted where shear in rivets in outstanding legs governs and, therefore, permit the same values as "A" Connections tabulated on page 252.

See pages 150 and 151 for weights of Standard Connections and minimum spans to which applicable.

HOLES $1\frac{5}{16}''$ — RIVETS $\frac{7}{8}''$


HH

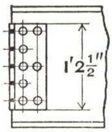
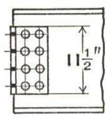
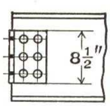
STANDARD BEAM CONNECTIONS

"H" & "HH" SERIES

ALLOWABLE LOADS IN KIPS


H

For beams framing opposite, see Note and Formula, page 254.

	Rivets in Outstanding Legs				Rivets in Web Legs		Maximum Value		
	H		HH						
	No.	Shear	No.	Shear	Bearing	Shear	Section	H	HH
							21 WF 142 and 125		144.3
							112		143.9†
							96		144.3
H 5-2Ls $6\times4\times\frac{7}{16}$	10	90.2	20	180.4	280 t	144.3	82	90.2	135.3†
HH 5-2Ls $6\times6\times\frac{7}{16}$					t=thickness of web		73	90.2	125.6†
							68	90.2	118 1†
							62	90.2	109.2†
							18 WF 114		142.9†
							105		131.9†
							96	72.2	120.9†
							85	72.2	125.3†
							77	72.2	112.1†
							70	72.2	102.5†
							64	72.2	93.6†
							60	72.2	98.7†
							55	72.2	91.9†
							50	72.2	83.8†
	8	72.2	16	144.3	280 t	144.3	16 WF 96		113.5†
H 4-2Ls $6\times4\times\frac{3}{8}$							88	72.2	105.9†
HH 4-2Ls $6\times6\times\frac{3}{8}$							78	72.2	112.2†
							71	72.2	102.1†
							64	72.2	92.1†
							58	72.2	83.9†
							50	72.2	80.3†
							45	72.2	72.5†
							40	63.9†	63.9†
							36	61.6†	61.6†
							14 WF 38	54.1	57.5†
							34	52.2†	52.2†
							30	48.6†	48.6†
	6	54.1	12	108.2	210 t	108.2*			
H 3-2Ls $6\times4\times\frac{3}{8}$							12 WF 36	48.5†	
HH 3-2Ls $6\times6\times\frac{3}{8}$							31	41.6†	
							27	37.3†	

"H" and "HH" Connections are not treated as standard by all fabricators. When so treated, the web rivets must be retained in number and position as shown in these sketches. Those fabricators who treat any connection heavier than the "A" Series as special, detail both field and shop rivets according to the general principles given on page 260. Whereas some fabricators fabricate "A" Connections by Symbol without detail drawings, "H", "HH", and special connections must always be detailed for all fabricators.

*This value is theoretical. It cannot be attained by the webs of any of the listed beams.
†The values tabulated for these connections have been reduced to those permitted by web bearing or web shear, whichever governs.
Values for "H" Connections have been omitted where shear in rivets in outstanding legs governs and, therefore, permit the same values as "A" Connections tabulated on page 253.

See pages 150 and 151 for weights of Standard Connections and minimum spans to which applicable.

RIVETS $\frac{3}{4}''$ HOLES $\frac{13}{16}''$

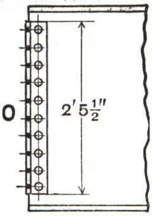
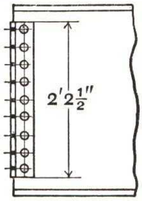
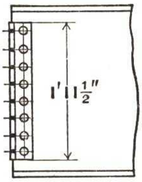
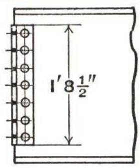
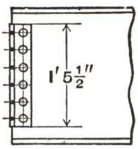
STANDARD BEAM CONNECTIONS

"B" SERIES

ALLOWABLE LOADS IN KIPS

B

These "B" Series Connections are "A.I.S.C. Standard" for the respective beams, and should in general be used for reactions not greater than those herein tabulated. For greater reactions use "K" or "KK" Connections, pages 258 and 259, or design special connections according to the general principles on page 261. For beams framing opposite, see Note and Formula, page 258.

Connection	Rivets in Outstanding Legs		Rivets in Web Legs		Maximum Value	
	No.	Shear	Bearing	Shear	Section	R
B 10  $2'5\frac{1}{2}''$ 2Ls $4 \times 3\frac{1}{2} \times \frac{7}{16}$	20	132.5	300 t t=thickness of web	132.5	36 WF (all weights)	132.5
B 9  $2'2\frac{1}{2}''$ 2Ls $4 \times 3\frac{1}{2} \times \frac{7}{16}$	18	119.3	270 t	119.3	33 WF (all weights)	119.3
B 8  $1'11\frac{1}{2}''$ 2Ls $4 \times 3\frac{1}{2} \times \frac{7}{16}$	16	106.0	240 t	106.0	30 WF (all weights)	106.0
B 7  $1'8\frac{1}{2}''$ 2Ls $4 \times 3\frac{1}{2} \times \frac{7}{16}$	14	92.8	210 t	92.8	27 WF (all weights)	92.8
B 6  $1'5\frac{1}{2}''$ 2Ls $4 \times 3\frac{1}{2} \times \frac{7}{16}$	12	79.5	180 t	79.5	24 WF 160 to 84 76 24 I (all weights)	79.5 79.2† 79.5

†The values tabulated for these connections have been reduced to those permitted by web bearing.

See pages 152 and 153 for weights of Standard Connections and minimum spans to which applicable.

HOLES 13/16" RIVETS 3/4"

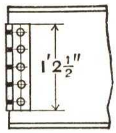
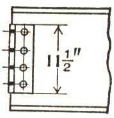
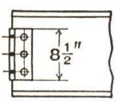
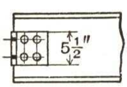
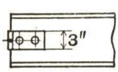
STANDARD BEAM CONNECTIONS

"B" SERIES

ALLOWABLE LOADS IN KIPS

B

These "B" Series Connections are "A.I.S.C. Standard" for the respective beams, and should in general be used for reactions not greater than those herein tabulated. For greater reactions use "K" or "KK" Connections, pages 258 and 259, or design special connections according to the general principles on page 261. For beams framing opposite, see Note and Formula, page 258.

	Rivets in Outstanding Legs		Rivets in Web Legs		Maximum Value			
	No.	Shear	Bearing	Shear	Section	R	Section	R
B 5  2Ls 4 x 3½ x 7/16	10	66.3	150 t t = thickness of web	66.3	21WF142 to 73 68 62	66.3 64.5† 60.0†	20I (all weights)	66.3
B 4  2Ls 4 x 3½ x 3/8	8	53.0	120 t	53.0	18WF114 to 77 70 64 60 55 50 16WF 96 to 64 58 50 45 40 36	53.0 52.6† 48.4† 49.9† 46.8† 43.0† 53.0 48.8† 45.6† 41.5† 36.8† 35.9†	18I (all weights) 15 I 50 42.9	53.0 53.0 49.2†
B 3  2Ls 4 x 3½ x 3/8	6	39.8	90 t	39.8	14 WF 38 34 30 12 WF 36 31 27	28.2† 25.8† 24.3† 27.5† 23.8† 21.6†	12 I 50 and 40.8 35 31.8	39.8 38.5† 31.5†
B 2  2Ls 6 x 4 x 3/8	4	26.5	120 t	53.0	10WF (all wts.) 8 WF 20 17	26.5 26.2† 23.9†	10I (35 and 25.4) 8I (23.0 & 18.4)	26.5 26.5
B 1  2Ls 6 x 4 x 3/8	2	13.3	60 t	26.5	7I (20 and 15.3) 6I (17.25 and 12.5)	13.3 13.3	5 I 14.75 10	13.3 12.6

†The values tabulated for these connections have been reduced to those permitted by web bearing or web shear, whichever governs.

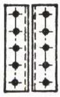
See pages 152 and 153 for weights of Standard Connections and minimum spans to which applicable.

RIVETS ¾″ HOLES $^{13}/_{16}$″

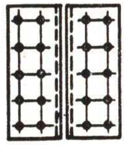
STANDARD BEAM CONNECTIONS

"K" & "KK" SERIES

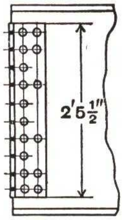
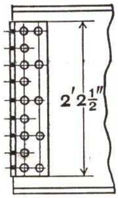
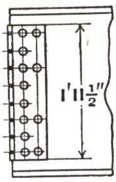
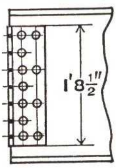
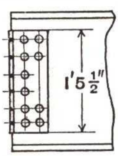
ALLOWABLE LOADS IN KIPS

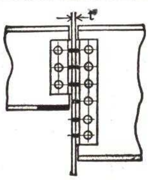


K



KK

Connection		Rivets in Outstanding Legs				Rivets in Web Legs		Maximum Value		
		K		KK						
		No.	Shear	No.	Shear	Bearing	Shear	Section	K	KK
K 10-2L^s 6×4×7⁄16 KK 10-2L^s 6×6×7⁄16				40	265.1	480 t t=thickness of web	218.1	36 WF (all weights)		212.1
K 9-2L^s 6×4×7⁄16 KK 9-2L^s 6×6×7⁄16				36	238.6	420 t	185.6	33 WF (all weights)		185.6
K 8-2L^s 6×4×7⁄16 KK 8-2L^s 6×6×7⁄16				32	212.1	360 t	159.0	30 WF (all weights)		159.0
K 7-2L^s 6×4×7⁄16 KK 7-2L^s 6×6×7⁄16				28	185.6	330 t	145.8	27 WF (all weights)		145.8
K 6-2L^s 6×4×7⁄16 KK 6-2L^s 6×6×7⁄16		12	79.5	24	159.0	300 t	132.5	24 WF 160 to 84 76	 79.5	132.0† 132.0†



Note for all Connections:

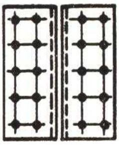
Where some of the rivets in outstanding legs frame opposite, through a plate less than $^7/_{16}$″ thick, reduce above values for outstanding legs by 0.94 nk, where n = number of rivets framing opposite and k = number of sixteenths by which t is less than $^7/_{16}$″. Note that value of rivets in web legs may still control. Above formula for ¾″ rivets only.

†The values tabulated for these connections have been reduced to those permitted by web bearing.

Values for "K" Connections have been omitted where shear in rivets in outstanding legs governs and, therefore, permit the same values as "B" Connections tabulated on page 256.

See pages 152 and 153 for weights of Standard Connections and minimum spans to which applicable.

HOLES 13/16" RIVETS 3/4"



KK

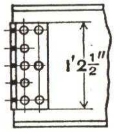
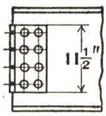
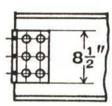
STANDARD BEAM CONNECTIONS

"K" & "KK" SERIES

ALLOWABLE LOADS IN KIPS

K

For beams framing opposite, see Note and Formula, page 258.

	Rivets in Outstanding Legs				Rivets in Web Legs		Maximum Value		
	K		KK						
	No.	Shear	No.	Shear	Bearing	Shear	Section	K	KK
 K 5-2Ls 6x4x7/16 KK 5-2Ls 6x6x7/16	10	66.3	20	132.5	240 t (t=thickness of web)	106.0	21 WF 142 to 73		106.0
							68	66.3	103.2†
							62	66.3	96.0†
 K 4-2Ls 6x4x3/8 KK 4-2Ls 6x6x3/8	8	53.0	16	106.0	240 t	106.0	18 WF 114 to 77		106.0
							70	53.0	102.5†
							64	53.0	93.6†
							60	53.0	98.7†
							55	53.0	91.9†
							50	53.0	83.8†
							16 WF 96		106.0
							88		105.9†
							78		106.0
							71		102.1†
							64		92.1†
							58	53.0	83.9†
							50	53.0	80.3†
							45	53.0	72.5†
							40	53.0	63.9†
							36	53.0	61.6†
 K 3-2Ls 6x4x3/8 KK 3-2Ls 6x6x3/8	6	39.8	12	79.5	180 t	79.5*	14 WF 38	39.8	56.3†
							34	39.8	51.7†
							30	39.8	48.6†
							12 WF 36	39.8	48.5†
							31	39.8	41.6†
							27	37.4†	37.4†

"K" and "KK" Connections are not treated as standard by all fabricators. When so treated, the web rivets must be retained in number and position as shown in these sketches. Those fabricators who treat any connection heavier than the "K" Series as special, detail both field and shop rivets according to the general principles given on page 261. Whereas some fabricators fabricate "B" Connections by Symbol without detail drawings, "K", "KK", and special connections must always be detailed for all fabricators.

*This value is theoretical. It cannot be attained by the webs of any of the listed beams.
†The values tabulated for these connections have been reduced to those permitted by web bearing or web shear, whichever governs.

Values for "K" Connections have been omitted where shear in rivets in outstanding legs governs and, therefore, permit the same values as "B" Connections tabulated on page 257.

See pages 152 and 153 for weights of Standard Connections and minimum spans to which applicable.

RIVETS 7/8″

HOLES 15/16″

SPECIAL BEAM CONNECTIONS

Examples below illustrate methods of designing connections for beams with reactions too large to be carried by Standard Connections.

Value of One Rivet

Single shear in outstanding leg.. 9.02 Kips
Enclosed bearing on web.. 35.0t Kips
Maximum (double shear)... 18.04 Kips

Minimum web thickness "t" to develop double shear.........0.515 inch.
Minimum web thickness "t" to develop single shear..........0.322 inch.

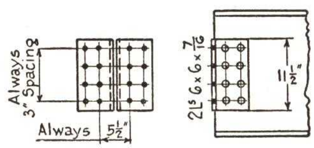
Thin Webs

When web "t" is less than .515″ it may occur that the standard "A" Connection provides sufficient shear capacity in outstanding legs, but insufficient web bearing capacity. For all such cases a standard "H" Connection has been tabulated.

Heavy Shears

When, as by reason of short span or heavy loading the shear exceeds the shear capacity of a standard "A" Connection, three courses are available:

1. If the web rivets of a standard "A" or "H" Connection are adequate for web bearing, use 1″ rivets in its outstanding legs, thus increasing its shear capacity by 30%.
2. Use a standard "HH" Connection as tabulated.
3. Detail both legs, using rivet values at top of this page.



24 WF 130 t = .565″

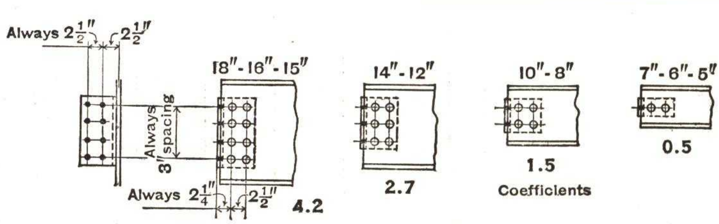
Shear : 140.0 Kips

O. S. Legs $\frac{140.0}{9.02} = 15.6$ rivets

Web Legs $\frac{140.0}{18.04} = 7.8$ rivets

In all cases regard must be had to the note near the foot of page 254.

One-sided Connections



Avoid, where practicable, and do not use for beams over 18″. For capacity, multiply least value of one rivet by coefficient shown. For gages other than those shown, the coefficients will vary and must be computed by the general formula for Case II, page 266. Eccentricity should be provided for in the outstanding leg only, unless shop riveted leg of angle exceeds 6″ for 7/8″ rivets or smaller, or 7″ for 1″ rivets or larger, when eccentricity should be provided for in both legs.

All the above connections are special and must be detailed.

SPECIAL BEAM CONNECTIONS

Examples below illustrate methods of designing connections for beams with reactions too large to be carried by Standard Connections.

Value of One Rivet

Single shear in outstanding leg	6.63 Kips
Enclosed bearing on web	30.0t Kips
Maximum (double shear)	13.25 Kips

Minimum web thickness "t" to develop double shear........0.442 inch.
Minimum web thickness "t" to develop single shear..........0.276 inch.

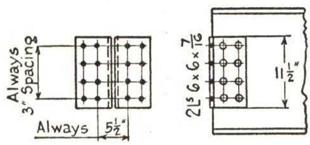
Thin Webs

When web "t" is less than .442″ it may occur that the standard "B" Connection provides sufficient shear capacity in outstanding legs, but insufficient web bearing capacity. For all such cases a standard "K" Connection has been tabulated.

Heavy Shears

When, as by reason of short span or heavy loading, the shear exceeds the shear capacity of a standard "B" Connection, three courses are available:

1. If the web rivets of a standard "B" or "K" Connection are adequate for web bearing, use $\frac{7}{8}''$ rivets in its outstanding legs, thus increasing its shear capacity by 36%.
2. Use a standard "KK" Connection as tabulated.
3. Detail both legs, using rivet values at top of this page.



21 WF 112 t = .527″

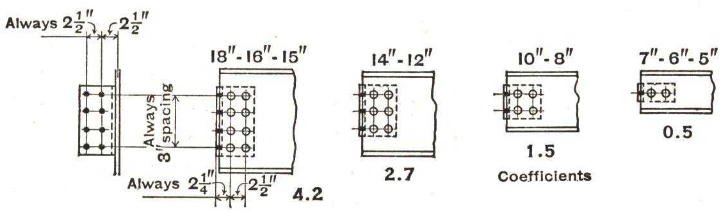
Shear : 105.0 Kips

$$\text{O. S. Legs}\ \frac{105.0}{6.63} = 15.8 \text{ rivets}$$

$$\text{Web Legs}\ \frac{105.0}{13.25} = 7.9 \text{ rivets}$$

In all cases regard must be had to the note near the foot of page 258.

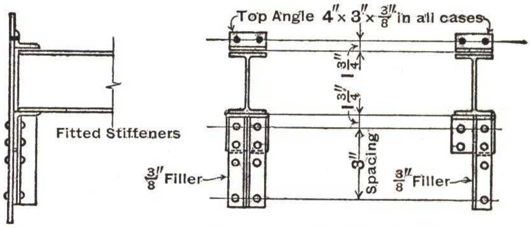
One-sided Connections



Avoid, where practicable, and do not use for beams over 18″. For capacity, multiply least value of one rivet by coefficient shown. For gages other than those shown, the coefficients will vary and must be computed by the general formula for Case II, page 266. Eccentricity should be provided for in the outstanding leg only, unless shop riveted leg of angle exceeds 6″ for $\frac{7}{8}''$ rivets or smaller, or 7″ for 1″ rivets or larger, when eccentricity should be provided for in both legs.

All the above connections are special and must be detailed.

STIFFENED BEAM SEATS



Rivet Diameter	Single Shear One Rivet	No. of Rivets in One Row	Size of Seat Angle	Stiffener Angles: Size Outstanding Leg Listed First	Stiffener Angles: Bearing Value of Two Angles in Kips	Stiffener Angles: Gage of Angle	Capacity of Rivet Group in Kips: Two Stiff.	Capacity of Rivet Group in Kips: One Stiff.	Weight of Connection Lb.: Two Stiff.	Weight of Connection Lb.: One Stiff.
3/4″	6.63	3	6 x 4 x 3/8	3½ x 3 x 5/16	51	1¾	40		28	
		4	6 x 4 x 3/8	3½ x 3 x 5/16	51	1¾	53		35	
		4	6 x 4 x 3/8	3½ x 4 x 5/16	51	2½	38		42	
		5	6 x 4 x 3/8	3½ x 3 x 7/16	71	1¾	66		48	
		5	6 x 4 x 3/8	3½ x 4 x 5/16	51	2½	51		50	
		6	6 x 4 x 3/8	3½ x 3 x ½	81	1¾	80	40	59	36
		6	6 x 4 x 3/8	3½ x 4 x 7/16	71	2½	65		66	
		7	6 x 4 x 3/8	3½ x 4 x ½	81	2½	79	39	80	47
7/8″	9.02	3	6 x 4 x 3/8	3½ x 3 x 3/8	61	1¾	54		33	
		4	6 x 4 x 3/8	3½ x 3 x 7/16	71	1¾	72	36	44	30
		4	6 x 4 x 3/8	3½ x 4 x 5/16	51	2½	50		46	
		5	6 x 4 x 3/8	3½ x 3 x ½	81	1¾	90	45	56	36
		5	6 x 4 x 3/8	3½ x 4 x 7/16	71	2½	69		62	
		6	6 x 6 x 3/8	5 x 3½ x 7/16	106	1¾	108	54	72	45
		6	6 x 6 x 3/8	4 x 4 x ½	95	2½	88	44	81	51
		7	6 x 6 x 3/8	5 x 3½ x ½	122	1¾	126	63	88	53
1″	11.78	3	6 x 4 x 3/8	3½ x 3½ x 7/16	71	2	71		39	
		3	6 x 4 x 3/8	3½ x 4 x 3/8	61	2½	44		42	
		4	6 x 4 x 3/8	3½ x 3½ x ½	81	2	94	47	52	35
		4	6 x 4 x 3/8	3½ x 4 x 7/16	71	2½	67		56	
		5	6 x 6 x 3/8	5 x 3½ x ½	122	2	118	59	71	46
		5	6 x 6 x 3/8	4 x 4 x ½	95	2½	91	45	75	49
		6	6 x 6 x 3/8	5 x 5 x ½	122	2½	115	58	97	61

Effective length of stiffener bearing is assumed ½ inch less than length of outstanding leg.

Capacities based on rivets are for single shear, and should be investigated for bearing when seats connect to thin material or when seats on opposite sides of a carrying member have rivets in common.

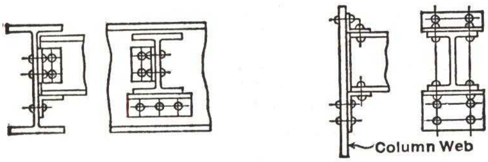
Torsion on rivet groups is figured in accordance with the procedure outlined on Page 264 under Stiffened Beam Seats. Angles shown in contact in sketch above may be separated in order that gage in angle may coincide with standard gage in column.

For capacities under 35 kips unstiffened seat angles should be used. (See Page 263.)

Weight of connection includes top and seat angles, fillers, stiffeners, and shop rivets shown in sketch, computed by A. I. S. C. Code of Standard Practice. Top and seat angles are estimated 7½″ long where stiffener gage is 1¾″, and 9½″ long where it is 2½″. Fillers under double stiffeners are estimated same width as length of top and seat angles; under single stiffeners, same width as stiffeners.

BEAM SEATS WITHOUT STIFFENERS

ALLOWABLE LOADS IN KIPS



Outstanding Leg of Angle 4″

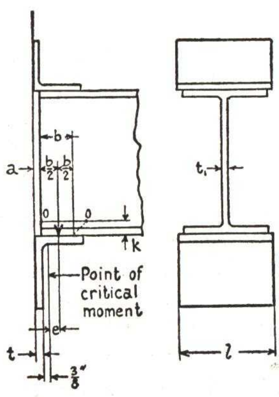
Thickness of Beam Web	Length = 6″						Length = 8″					
	Thickness of Seat Angle						Thickness of Seat Angle					
	3/8″	1/2″	5/8″	3/4″	7/8″	1″	3/8″	1/2″	5/8″	3/4″	7/8″	1″
3/16	6	9	11	14	16		7	10	13	15	16	
1/4	8	11	14	17	20	23	9	12	16	19	22	23
5/16	10	15	18	21	25	28	11	16	20	24	27	31
3/8	11	17	22	26	30	34	12	19	24	28	32	35
7/16	12	18	25	30	34	35	13	21	27	32	35	
1/2	12	20	28	34	35		14	22	31	35		
9/16	14	21	30	35			15	24	34	35		

Above values are to be used only when beam has a top angle or side lug.

For values over 35 kips stiffened beam seats should be used. (See page 262.)

Above table is based on effective bearing beginning ½″ from back of seat angle. Values for seat angles of lengths other than 6″ or 8″ may be interpolated from the above table.

The following method of design, using a maximum bending stress of 24,000 pounds per square inch, is recommended. (The 24,000 pound unit stress is used, as the seat angle being fastened to the beam is restrained, and the true moment is somewhat less than for a simple cantilever.)



R = Reaction of beam, in kips.
t = Thickness of seat angle, in inches.
l = Length of seat angle. (Max. effective length = 9″)
a = Distance from back of seat angle to beam, in inches.
k = Distance from bottom of beam to top of fillet, in inches.

$$b = \text{Effective length of bearing} = \frac{P}{f_1\,t_1} - k = \frac{P}{24\,t_1} - k,$$

but not less than ½ (o-o).
where f_1 = allowable stress at toe of fillet, A.I.S.C. Specification, Sec. 26(h) = 24 kips p. s. i.; and
t_1 = thickness of beam web, in inches.

$$e = \frac{b}{2} + a - t - \frac{3}{8}$$

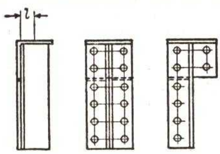
$$M = Re = \frac{24\,lt^2}{6}$$

$$R = \frac{24\,lt^2}{6e} = \frac{4\,lt^2}{e}$$

ECCENTRIC BEAM CONNECTIONS

STIFFENED BEAM SEATS. See page 262 for table of Stiffened Beam Seats.

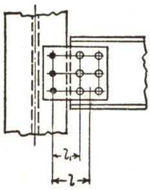
(a) **Stiffeners up to 5″ Outstanding Leg.** Torsion should be figured on rivet groups for gages $2\frac{1}{2}''$ and over (Case I, page 266). Double angles as well as single angles should be figured for torsion because outstanding legs are not riveted and, hence, the two angles act independently. Eccentricity on outstanding legs may be neglected.



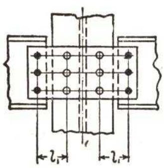
(b) **Stiffeners over 5″ Outstanding Legs and Gages under $2\frac{1}{2}''$.** Eccentricity should be figured on outstanding leg and the use of method of design shown for Fig. 3, page 265, is recommended. Assume lever arm as $\frac{1}{2}$ (outstanding leg minus $\frac{1}{2}''$). See page 267 for required thickness of stiffeners.

(c) **Stiffeners over 5″ Outstanding Legs and Gages $2\frac{1}{2}''$ and Over.** Rivet the outstanding legs together and compute as for (b).

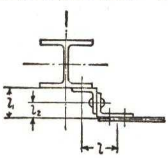
BEAM TO COLUMN CONNECTION. To avoid moment in the column full eccentricity in the rivets connecting plate to beam should be figured. Lever arm l should be used. A coefficient for this rivet group, for ordinary cases, can be found in the tables on page 266, and for other cases may be calculated from the formulas given there. Field rivets connecting plate to column should be used (least number) if beam can be erected and if there are no interfering details in the web of the column. The plate should figure for a moment with lever arm l_1. See page 268 for table of Net Section Moduli of Plates.



SYMMETRICAL BEAM TO COLUMN CONNECTIONS. A single plate across the column may be used. If the reactions of the two beams are equal there is no eccentricity to figure on either beams or columns. The case of live load on one beam only must, however, be considered. Where for this or other reason the beam reactions are unequal, figure the rivets in the column for the sum of the reactions and the difference of the moments, taken to the center of the connection. See page 266. Plate should figure for greater moment with lever arm l_1. See page 268 for table of Net Section Moduli of Plates.



ZEE CONNECTIONS. In general avoid the use of zee connections. Eccentricity in rivets connecting connection angle to the beam should be figured, using the lever arm l. Eccentricity in rivets connecting connection angle to column, with a lever arm of l_1, should be figured. The thickness of the angle should be ample to resist the bending moment. See page 267. Eccentricity in rivets connecting the two connection angles should be figured if the lever arm l_2 is $2\frac{1}{2}''$ or more. The least number of field rivets should be used.



RIVET GROUPS UNDER ECCENTRIC APPLICATION OF LOAD

When a group of rivets carries an eccentric load, as in Fig. 1, the several rivets in such a group are not equally stressed. Each carries an equal share ($r = P/2n$) of the vertical load P; and each carries in addition a force R due to moment, which is proportional to its distance a from the center of the rivet group and acts at right angles to the line connecting the rivet in question to the center of the group. The total stress on the rivet is the resultant of the two components defined above; it is greatest for the rivet which is on the side toward the load, and farthest from the center of the group.

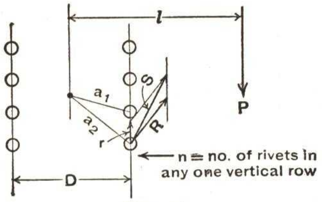


FIG. 1

Let a_1, a_2, etc., be the distances of respective rivets from center of group.

Let x = the unknown force due to moment on an imaginary rivet at unit distance from center of group.

Then, on any rivet at distance a, the force = ax, and its moment = a^2x.

Adding $(a_1)^2x + (a_2)^2x + \ldots$ etc., and equating to the moment Pl, solve for x.

Then R (Fig. 1) = maximum ax, and S is found from R and r as shown in Fig. 1.

The group must be such in number and arrangement of rivets that S, the greatest stress on any rivet, does not exceed the value allowed by the Specification.

For any rivet group and any given lever arm of applied load a coefficient C may be found, such that C times the allowable value of one rivet equals the total load P permissible on the connection.

Thus $P = C \times S$.

Or, knowing P, and dividing by the allowable rivet value S, the necessary coefficient C is obtained, and a rivet group must be employed for which the coefficient is of that magnitude or greater.

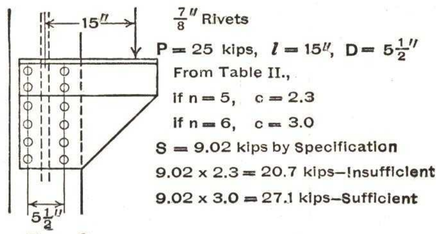


FIG. 2

General expressions for the coefficient C are very complex, and for all except simple, symmetrical cases the joint must be detailed by a cut-and-try process based on the foregoing principles and without deriving of coefficients. For the simplest cases occurring repeatedly in practice, the coefficients C are given in the Tables on page 266; in connection with Fig. 2 is given an example of the use thereof.

In the case of eccentric brackets of the type shown in Fig. 3, in which the moment produces tension on the rivets, there is no exact knowledge as to the location of the neutral axis; it probably lies somewhere below the center line of the connection. Nor is there exact knowledge of the permissible combination of tension with vertical shear on the uppermost rivets. A safe and accepted method of design for brackets of the type shown is to consider the rivets to be under an eccentric loading similar to that exemplified in Table I, page 266. The coefficient C for such cases will be twice the values tabulated in Table I to conform with the two vertical rows of rivets; the resultant stress on one extreme rivet not to exceed the A. I. S. C. Specification allowance of 15.0 kips per square inch.

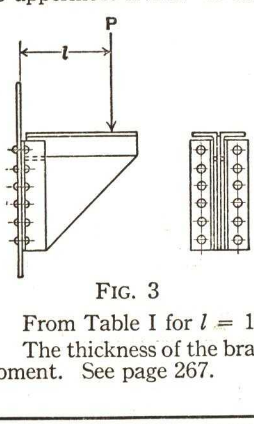


FIG. 3

Example:

P = 22 kips $l = 12''$ ¾″ rivets, 3″ pitch.

Allowable stress on one rivet = $15.0 \times .4418 =$ 6.63 kips. (A. I. S. C. Spec. Sect. 12 (b).)

$$C = \frac{P}{2 \times S} = \frac{22}{2 \times 6.63} = 1.66$$

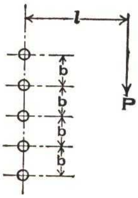
From Table I for $l = 12''$ six rivets are required in each of two vertical rows.

The thickness of the bracket connection angles should be ample to resist the bending moment. See page 267.

RIVET GROUPS UNDER ECCENTRIC APPLICATION OF LOAD

Nomenclature:
n = total number of rivets in any one vertical row.
P = permissible load, acting with lever arm l.
S = permissible load on one rivet by Specification.
C = coefficient as tabulated below.
P = C × S; or, knowing P, required minimum $C = \frac{P}{S}$

Case I

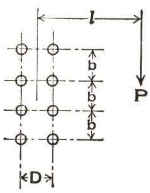


In Table, b = 3″

n \ l	1″	2″	3″	6″	9″	12″	15″	18″	21″	24″
2	1.7	1.2	.89	.49	.33	.25	.20	.17	.14	.12
3	2.7	2.1	1.7	.95	.65	.49	.40	.33	.28	.25
4	3.7	3.1	2.6	1.5	1.1	.82	.66	.55	.47	.41
5	4.7	4.2	3.5	2.2	1.6	1.2	.98	.82	.71	.62
6	5.8	5.2	4.6	3.0	2.2	1.7	1.4	1.1	.99	.87
7	6.8	6.3	5.6	3.9	2.8	2.2	1.8	1.5	1.3	1.2
8	7.8	7.3	6.7	4.8	3.6	2.8	2.3	1.9	1.7	1.5
9	8.8	8.4	7.7	5.8	4.4	3.5	2.8	2.4	2.1	1.8
10	9.8	9.4	8.8	6.8	5.2	4.2	3.4	2.9	2.5	2.2
11	10.9	10.4	9.8	7.8	6.1	4.9	4.1	3.5	3.0	2.7
12	11.9	11.5	10.9	8.8	7.0	5.7	4.8	4.1	3.5	3.1

In general, $$C = \frac{n}{\sqrt{\left[\frac{6l}{(n+1)\,b}\right]^2 + 1}}$$

Case II

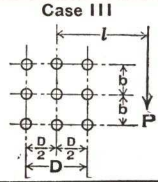


In Table, b = 3″ and D = 5½″ or 9½″

l	1″		2″		3″		6″		9″		12″		15″		18″		21″		24″	
n \ D	5½	9½	5½	9½	5½	9½	5½	9½	5½	9½	5½	9½	5½	9½	5½	9½	5½	9½	5½	9½
2	3.1	3.4	2.5	2.9	2.1	2.5	1.4	1.8	1.1	1.4	0.8	1.2	0.7	1.0	0.6	0.9	0.5	0.8	0.5	0.7
3	4.9	5.1	4.1	4.4	3.4	3.9	2.3	2.9	1.7	2.2	1.4	1.8	1.1	1.6	1.0	1.4	0.9	1.2	0.8	1.1
4	6.8	7.0	5.8	6.1	5.0	5.4	3.4	4.0	2.5	3.1	2.0	2.6	1.7	2.2	1.4	1.9	1.2	1.7	1.1	1.5
5	8.8	8.9	7.7	7.9	6.7	7.0	4.6	5.2	3.5	4.1	2.8	3.3	2.3	2.8	1.9	2.4	1.7	2.1	1.5	1.9
6	10.9	10.8	9.6	9.7	8.5	8.7	6.0	6.5	4.5	5.1	3.6	4.2	3.0	3.6	2.6	3.1	2.2	2.7	2.0	2.4
7	12.9	12.8	11.7	11.6	10.4	10.6	7.5	8.0	5.8	6.3	4.6	5.2	3.8	4.4	3.3	3.8	2.8	3.3	2.5	3.0
8	15.0	14.8	13.7	13.6	12.4	12.4	9.2	9.6	7.1	7.6	5.7	6.2	4.8	5.3	4.1	4.6	3.5	4.0	3.1	3.6
9	17.0	16.9	15.8	15.6	14.5	14.4	11.0	11.2	8.6	9.0	6.9	7.4	5.8	6.3	4.9	5.4	4.3	4.8	3.8	4.3
10	19.1	18.9	17.9	17.7	16.6	16.4	12.8	13.0	10.1	10.5	8.2	8.7	6.9	7.4	5.9	6.4	5.2	5.6	4.6	5.0
11	21.2	20.9	20.0	19.7	18.7	18.4	14.8	14.8	11.8	12.1	9.7	10.0	8.1	8.5	7.0	7.4	6.1	6.5	5.4	5.8
12	23.2	23.0	22.1	21.8	20.8	20.5	16.8	16.7	13.5	13.7	11.2	11.4	9.4	9.8	8.1	8.5	7.1	7.5	6.3	6.7

In general, $$C = \frac{n}{\sqrt{\left[\frac{l\,(n-1)\,b}{D^2 + \frac{1}{3}(n^2-1)\,b^2}\right]^2 + \left[\frac{l\,D}{D^2 + \frac{1}{3}(n^2-1)\,b^2} + \frac{1}{2}\right]^2}}$$

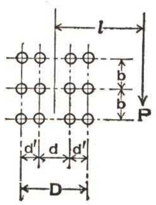
Case III



Case III, not tabulated.

In general, $$C = \frac{n}{\sqrt{\left[\frac{l\,(n-1)\,b}{D^2 + \frac{1}{2}(n^2-1)\,b^2}\right]^2 + \left[\frac{l\,D}{D^2 + \frac{1}{3}(n^2-1)\,b^2} + \frac{1}{3}\right]^2}}$$

Case IV



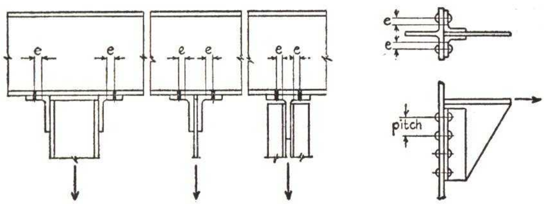
In Table, b = 3″
d′ = 2½″ d′ = 3″
d = 4½″ d = 5½″
d′ = 2½″ d′ = 3″
D = 9½″ D = 11½″

l	1″		2″		3″		6″		9″		12″		15″		18″		21″		24″	
n \ D	9½	11½	9½	11½	9½	11½	9½	11½	9½	11½	9½	11½	9½	11½	9½	11½	9½	11½	9½	11½
2	6.2	6.4	5.0	5.3	4.2	4.5	2.8	3.1	2.1	2.4	1.7	1.9	1.4	1.6	1.2	1.4	1.1	1.2	1.0	1.1
3	9.6	9.8	8.0	8.2	6.7	7.1	4.6	5.0	3.5	3.8	2.8	3.1	2.3	2.6	2.0	2.2	1.8	2.0	1.6	1.8
4	13.3	13.4	11.2	11.5	9.7	10.0	6.7	7.1	5.1	5.4	4.1	4.4	3.4	3.7	2.9	3.2	2.6	2.8	2.3	2.5
5	17.2	17.2	14.8	15.0	12.9	13.1	9.1	9.4	6.9	7.3	5.6	5.9	4.7	5.0	4.0	4.3	3.5	3.8	3.1	3.4
6	21.2	21.1	18.6	18.6	16.4	16.5	11.7	12.1	9.0	9.4	7.3	7.6	6.1	6.4	5.2	5.5	4.6	4.9	4.1	4.3
7	25.2	25.1	22.5	22.5	20.1	20.1	14.7	14.9	11.3	11.7	9.2	9.5	7.7	8.0	6.6	6.9	5.8	6.1	5.1	5.4
8	29.3	29.2	26.5	26.4	23.9	23.9	17.8	18.0	13.9	14.2	11.3	11.6	9.5	9.8	8.2	8.5	7.2	7.5	6.4	6.6
9	33.4	33.3	30.6	30.5	27.9	27.8	21.2	21.3	16.7	16.9	13.7	13.9	11.5	11.8	9.9	10.2	8.7	9.0	7.7	8.0
10	37.6	37.4	34.8	34.6	32.0	31.8	24.8	24.8	19.7	19.9	16.2	16.4	13.7	13.9	11.8	12.1	10.4	10.6	9.2	9.5
11	41.7	41.5	39.0	38.7	36.2	35.9	28.5	28.5	22.9	23.0	18.9	19.1	16.0	16.2	13.9	14.1	12.2	12.4	10.9	11.1
12	45.8	45.6	43.2	42.8	40.3	40.0	32.4	32.2	26.3	26.3	21.8	21.9	18.5	18.7	16.0	16.3	14.1	14.4	12.6	12.8

In general, $$C = \frac{n}{\sqrt{\left[\frac{l\,(n-1)\,b}{d^2 + D^2 + \frac{2}{3}(n^2-1)\,b^2}\right]^2 + \left[\frac{l\,D}{d^2 + D^2 + \frac{2}{3}(n^2-1)\,b^2} + \frac{1}{4}\right]^2}}$$

ANGLE AND STRUCTURAL TEE CONNECTIONS
FOR HANGERS AND BRACKETS

ALLOWABLE LOADS IN KIPS PER INCH ON TWO ANGLES OR STRUCTURAL TEE



Hangers Brackets

Arm "e" In.	Thickness of Angle or Flange of Tee, "t", Inches															
	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1	$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{4}$
$\frac{1}{2}$	2.60	3.56	5.12	6.68	8.40	10.44	12.58	15.00	17.56	20.40	23.40	26.60	30.20	33.60	37.60	41.60
$\frac{3}{4}$	1.74	2.50	3.42	4.44	5.60	6.96	8.38	9.96	11.70	13.60	15.60	17.78	20.20	22.40	25.00	27.60
1	1.30	1.88	2.56	3.33	4.20	5.20	6.30	7.50	8.80	10.20	11.70	13.33	15.10	16.80	18.80	20.80
$1\frac{1}{4}$	1.04	1.50	2.06	2.67	3.36	4.16	5.04	6.00	7.04	8.16	9.36	10.67	12.00	13.46	15.00	16.60
$1\frac{1}{2}$	.88	1.26	1.70	2.22	2.80	3.48	4.20	5.00	5.86	6.80	7.80	8.88	10.00	11.20	12.50	13.80
$1\frac{3}{4}$	.74	1.08	1.46	1.90	2.40	2.98	3.60	4.28	5.04	5.84	6.68	7.62	8.60	9.64	10.70	11.90
2	.66	.94	1.28	1.66	2.10	2.60	3.16	3.74	4.40	5.10	5.86	6.68	7.52	8.40	9.36	10.38
$2\frac{1}{4}$	.58	.84	1.14	1.48	1.88	2.32	2.80	3.33	3.92	4.54	5.20	5.92	6.70	7.46	8.36	9.22
$2\frac{1}{2}$	.52	.76	1.02	1.33	1.68	2.08	2.52	3.00	3.52	4.08	4.68	5.33	6.04	6.72	7.50	8.30
$2\frac{3}{4}$	.48	.68	.94	1.22	1.54	1.90	2.30	2.72	3.20	3.72	4.26	4.86	5.48	6.12	6.80	7.54
3	.44	.62	.86	1.12	1.40	1.74	2.10	2.50	2.94	3.40	3.92	4.44	5.02	5.60	6.26	6.92
$3\frac{1}{4}$	.40	.58	.78	1.02	1.30	1.60	1.94	2.30	2.72	3.14	3.60	4.10	4.62	5.16	5.76	6.38

For single unrestrained angles use one-quarter of the loads tabulated above.

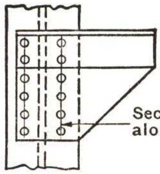
The following method of design using a maximum bending stress of 20 000 p.s.i., is recommended. Angles and structural tees are considered restrained in cases shown above or in similar cases. Point of critical moment is assumed at tangent of fillet of outstanding leg of angle or tee.

$$M = \frac{P}{2} \times \frac{e}{2} = \frac{20\ t^2}{6} \qquad\qquad P = \frac{80\ t^2}{6e} = \frac{13.33\ t^2}{e}$$

where P = Allowable load on two angles or structural tee in kips per linear inch.
e = Distance from tangent of fillet of angle or tee to center of rivet, in inches. (e/2 is the lever arm used to determine moment because angles and tees are considered restrained.)
t = Thickness of angle or flange of tee, in inches.

For brackets as shown above and in Fig. 3, page 265, and for beam seat stiffener angles page 262, divide the tension in the two top rivets by the rivet pitch to obtain the load per linear inch of two angles.

NET SECTION MODULI OF PLATES



Section Moduli taken along this line

Diameter of holes assumed ⅛″ larger than nominal diameter of rivet

Rivets spaced 3″ vertically

No. of Rivets in One Vertical Line	Depth of Plate in Inches	¾″ RIVETS					⅞″ RIVETS					1″ RIVETS				
		Thickness of Plate, In.					Thickness of Plate, In.					Thickness of Plate, In.				
		¼	⅜	½	⅝	¾	⅜	½	⅝	¾	⅞	½	⅝	¾	⅞	1
2	6	1.2	1.8	2.3	2.9	3.5	1.7	2.3	2.9	3.4	4.0	2.2	2.7	3.2	3.8	4.3
3	9	2.5	3.8	5.0	6.3	7.5	3.6	4.8	5.9	7.1	8.3	4.5	5.6	6.8	7.9	9.0
4	12	4.4	6.3	8.7	11	13	6.2	8.2	10	12	14	7.8	9.7	12	14	16
5	15	6.8	10	14	17	20	10	13	16	19	22	12	15	18	21	24
6	18	9.6	15	19	24	29	14	18	23	27	32	17	21	26	30	34
7	21	13	20	26	33	39	19	25	31	37	43	23	29	35	41	47
8	24	17	26	34	43	51	24	32	40	48	56	30	38	45	53	61
9	27	22	32	43	54	65	31	41	51	61	71	38	48	57	67	77
10	30	27	40	53	67	80	38	50	63	75	88	47	59	71	83	94
12	36	38	58	77	96	115	54	72	90	108	126	68	85	102	119	136
14	42	52	78	104	130	157	74	98	123	147	172	92	115	138	161	184
16	48	68	102	136	170	204	96	128	160	192	224	120	150	180	211	241
18	54	86	129	172	215	259	122	162	203	243	284	152	190	228	266	304
20	60	106	160	213	266	319	150	200	250	300	350	188	235	282	329	376
22	66	129	193	257	322	386	182	242	303	363	424	227	284	341	398	454
24	72	153	230	306	383	459	216	288	360	432	504	270	338	406	473	541
26	78	180	270	359	449	539	254	338	423	507	592	317	397	476	555	634
28	84	208	313	417	521	625	294	392	490	588	686	368	460	552	644	736
30	90	240	359	478	598	718	338	450	563	675	788	422	528	633	739	845
32	96	272	408	544	680	816	384	512	640	768	896	480	600	721	841	961
34	102	308	461	614	768	922	434	578	723	867	1012	542	678	813	949	1085
36	108	344	517	689	861	1033	486	648	810	972	1134	608	760	912	1064	1216

Interpolate for intermediate thicknesses of plates.

PINS

AREAS AND WEIGHTS

VALUES IN SHEAR, BEARING AND BENDING

Diameter of Pin	Area of Section	Weight per Foot		Section Modulus S	Shear		Bearing on Steel	Resisting Moment
		Rough Turned	Finished		Single 15,000 Pounds per Sq. In.	Double 15,000 Pounds per Sq. In.	1 Inch Thick 32,000 Pounds per Sq. In.	30,000 Pounds per Sq. In.
In.	In.²	Lb.	Lb.	In.³	Kips	Kips	Kips	Kip Inches
1	.79	....	2.67	.10	11.8	23.6	32	3.0
1¼	1.23	....	4.17	.19	18.4	36.8	40	5.7
1½	1.77	....	6.01	.33	26.5	53.0	48	9.9
1¾	2.41	....	8.18	.53	36.1	72.2	56	15.9
2	3.14	....	10.68	.79	47.1	94.3	64	23.7
2¼	3.98	....	13.52	1.12	59.6	119.3	72	33.6
2½	4.91	....	16.69	1.53	73.6	147.3	80	45.9
2¾	5.94	....	20.20	2.04	89.1	178.2	88	61.2
3	7.07	....	24.03	2.65	106.0	212.1	96	79.5
3¼	8.30	....	28.21	3.37	124.4	248.9	104	101.1
3½	9.62	....	32.71	4.21	144.3	288.6	112	126.3
3¾	11.05	....	37.55	5.18	165.7	331.4	120	155.4
4	12.57	....	42.73	6.28	188.5	377.0	128	188.4
4¼	14.19	....	48.23	7.54	212.8	425.6	136	226.2
4½	15.90	....	54.07	8.95	238.6	477.1	144	268.5
4¾	17.72	....	60.25	10.52	265.8	531.6	152	315.6
5	19.64	....	66.76	12.27	294.5	589.1	160	368.1
5¼	21.65	....	73.60	14.21	324.7	649.4	168	426.3
5½	23.76	....	80.78	16.33	356.4	712.7	176	489.9
5¾	25.97	....	88.29	18.66	389.5	779.0	184	559.8
6	28.27	100.2	96.13	21.21	424.1	848.2	192	636.3
6¼	30.68	108.5	104.3	23.97	460.2	920.4	200	719.1
6½	33.18	117.2	112.8	26.96	497.7	995.5	208	808.8
6¾	35.79	126.2	121.7	30.19	536.8	1074	216	905.7
7	38.49	135.6	130.9	33.68	577.3	1155	224	1010
7¼	41.28	145.2	140.4	37.41	619.2	1239	232	1122
7½	44.18	155.3	150.2	41.42	662.7	1325	240	1243
7¾	47.17	165.6	160.4	45.70	707.6	1415	248	1371
8	50.27	176.3	170.9	50.27	754.0	1508	256	1508
8¼	53.46	187.3	181.8	55.13	801.8	1604	264	1654
8½	56.75	198.7	192.9	60.29	851.2	1702	272	1809
8¾	60.13	210.3	204.5	65.79	902.0	1804	280	1973
9	63.62	222.4	216.3	71.57	954.3	1909	288	2147
9¼	67.20	234.7	228.5	77.70	1008	2016	296	2331
9½	70.88	247.4	241.0	84.18	1063	2127	304	2525
9¾	74.66	260.4	253.9	91.00	1120	2240	312	2730
10	78.54	273.8	267.0	98.18	1178	2356	320	2945

Pins up to 6 inch diameter are usually purchased as cold-rolled shafting and require no finish. Large pins are forgings, purchased rough-turned leaving 1/16″ finish all over.

POWER DRIVEN RIVETS
(SHOP AND FIELD)

AND

TURNED BOLTS IN REAMED HOLES

ALLOWABLE LOADS IN KIPS

Shear .... 15,000 lbs. per square inch
Bearing: S. S. .... 32,000 " " " "
" D. S. .... 40,000 " " " "

Rivet Dia.		1/2		5/8		3/4		7/8		1		1 1/8		1 1/4	
Area		.1963		.3068		.4418		.6013		.7854		.9940		1.2272	
Single Shear		2.95		4.60		6.63		9.02		11.78		14.91		18.41	
Double Shear		5.89		9.20		13.25		18.04		23.56		29.82		36.82	
Thickness of Plate		Bearing		Bearing		Bearing		Bearing		Bearing		Bearing		Bearing	
		32.0	40.0	32.0	40.0	32.0	40.0	32.0	40.0	32.0	40.0	32.0	40.0	32.0	40.0
.125	1/8	2.00	2.50	2.50	3.12	3.00	3.75								
.140		2.24	2.80	2.80	3.50	3.36	4.20	3.92	4.90						
.160		2.56	3.20	3.20	4.00	3.84	4.80	4.48	5.60						
.180		2.88	3.60	3.60	4.50	4.32	5.40	5.04	6.30						
.1875	3/16	3.00	3.75	3.75	4.69	4.50	5.62	5.25	6.56						
.200		......	4.00	4.00	5.00	4.80	6.00	5.60	7.00	6.40	8.00				
.220		......	4.40	4.40	5.50	5.28	6.60	6.16	7.70	7.04	8.80				
.240		......	4.80	4.80	6.00	5.76	7.20	6.72	8.40	7.68	9.60				
.250	1/4	......	5.00	......	6.25	6.00	7.50	7.00	8.75	8.00	10.0				
.260		......	5.20	......	6.50	6.24	7.80	7.28	9.10	8.32	10.4	9.36	11.7		
.280		......	5.60	......	7.00	6.72	8.40	7.84	9.80	8.96	11.2	10.1	12.6		
.300		......	6.00	......	7.50	......	9.00	8.40	10.5	9.60	12.0	10.8	13.5		
.3125	5/16	......	......	......	7.81	......	9.38	8.75	10.9	10.0	12.5	11.3	14.1		
.320		......	......	......	8.00	......	9.60	8.96	11.2	10.2	12.8	11.5	14.4	12.8	16.0
.340		......	......	......	8.50	......	10.2	......	11.9	10.9	13.6	12.2	15.3	13.6	17.0
.360		......	......	......	9.00	......	10.8	......	12.6	11.5	14.4	13.0	16.2	14.4	18.0
.375	3/8	......	......	......	9.38	......	11.3	......	13.1	12.0	15.0	13.5	16.9	15.0	18.8
.380		......	......	......	......	......	11.4	......	13.3	......	15.2	13.7	17.1	15.2	19.0
.400		......	......	......	......	......	12.0	......	14.0	......	16.0	14.4	18.0	16.0	20.0
.420		......	......	......	......	......	12.6	......	14.7	......	16.8	15.1	18.9	16.8	21.0
.4375	7/16	......	......	......	......	......	13.1	......	15.3	......	17.5	......	19.7	17.5	21.9
.440		......	......	......	......	......	......	......	15.4	......	17.6	......	19.8	17.6	22.0
.460		......	......	......	......	......	......	......	16.1	......	18.4	......	20.7	18.4	23.0
.480		......	......	......	......	......	......	......	16.8	......	19.2	......	21.6	......	24.0
.500	1/2	......	......	......	......	......	......	......	17.5	......	20.0	......	22.5	......	25.0
.520		......	......	......	......	......	......	......	18.2	......	20.8	......	23.4	......	26.0
.540		......	......	......	......	......	......	......	......	......	21.6	......	24.3	......	27.0
.560		......	......	......	......	......	......	......	......	......	22.4	......	25.2	......	28.0
.5625	9/16	......	......	......	......	......	......	......	......	......	22.5	......	25.3	......	28.1
.580		......	......	......	......	......	......	......	......	......	23.2	......	26.1	......	29.0
.600		......	......	......	......	......	......	......	......	......	24.0	......	27.0	......	30.0
.620		......	......	......	......	......	......	......	......	......	......	......	27.9	......	31.0
.625	5/8	......	......	......	......	......	......	......	......	......	......	......	28.1	......	31.3
.6875	11/16	......	......	......	......	......	......	......	......	......	......	......	30.9	......	34.4
.750	3/4	......	......	......	......	......	......	......	......	......	......	......	......	......	37.5

UNFINISHED BOLTS

ALLOWABLE LOADS IN KIPS

Shear .... 10,000 lbs. per square inch
Bearing: S. S. .... 20,000 " " " "
D. S. .... 25,000 " " " "

(See A.I.S.C. Specification Section 22(e) for conditional increase of ⅛)

Bolt Dia.		½		⅝		¾		⅞		1		1⅛		1¼	
Area		.1963		.3068		.4418		.6013		.7854		.9940		1.2272	
Single Shear		1.96		3.07		4.42		6.01		7.85		9.94		12.27	
Double Shear		3.93		6.14		8.84		12.03		15.71		19.88		24.54	
Thickness of Plate		Bearing		Bearing		Bearing		Bearing		Bearing		Bearing		Bearing	
		20.0	25.0	20.0	25.0	20.0	25.0	20.0	25.0	20.0	25.0	20.0	25.0	20.0	25.0
.125	⅛	1.25	1.56	1.56	1.95	1.88	2.35								
.140		1.40	1.75	1.75	2.19	2.10	2.63	2.45	3.06						
.160		1.60	2.00	2.00	2.50	2.40	3.00	2.80	3.50						
.180		1.80	2.25	2.25	2.81	2.70	3.38	3.15	3.94						
.1875	3/16	1.88	2.38	2.34	2.93	2.81	3.52	3.28	4.10						
.200		2.00	2.50	2.50	3.13	3.00	3.75	3.50	4.38	4.00	5.00				
.220			2.75	2.75	3.44	3.30	4.13	3.85	4.81	4.40	5.50				
.240			3.00	3.00	3.75	3.60	4.50	4.20	5.25	4.80	6.00				
.250	¼		3.13	3.13	3.91	3.75	4.69	4.38	5.47	5.00	6.25				
.260			3.25		4.06	3.90	4.88	4.55	5.69	5.20	6.50	5.85	7.31		
.280			3.50		4.38	4.20	5.25	4.90	6.13	5.60	7.00	6.30	7.88		
.300			3.75		4.69	4.50	5.63	5.25	6.56	6.00	7.50	6.75	8.44		
.3125	5/16		3.91		4.88		5.86	5.47	6.84	6.25	7.81	7.03	8.79		
.320			4.00		5.00		6.00	5.60	7.00	6.40	8.00	7.20	9.00	8.00	10.0
.340					5.31		6.38	5.95	7.44	6.80	8.50	7.65	9.56	8.50	10.6
.360					5.63		6.75		7.88	7.20	9.00	8.10	10.1	9.00	11.3
.375	⅜				5.86		7.03		8.20	7.50	9.38	8.44	10.6	9.38	11.7
.380					5.94		7.13		8.31	7.60	9.50	8.55	10.7	9.50	11.9
.400					6.25		7.50		8.75	8.00	10.0	9.00	11.3	10.0	12.5
.420							7.88		9.19		10.5	9.45	11.8	10.5	13.1
.4375	7/16						8.20		9.57		10.9	9.84	12.3	10.9	13.7
.440							8.25		9.63		11.0	9.90	12.4	11.0	13.8
.460							8.63		10.1		11.5		12.9	11.5	14.4
.480							9.00		10.5		12.0		13.5	12.0	15.0
.500	½								10.9		12.5		14.1	12.5	15.6
.520									11.4		13.0		14.6		16.3
.540									11.8		13.5		15.2		16.9
.560									12.3		14.0		15.7		17.5
.5625	9/16										14.1		15.8		17.6
.580											14.5		16.3		18.1
.600											15.0		16.9		18.8
.620											15.5		17.4		19.4
.625	⅝										15.6		17.6		19.5
.6875	11/16										17.2		19.3		21.5
.750	¾												21.1		23.4
.8125	13/16														25.4

PART IV

STANDARD SPECIFICATIONS AND CODES

AMERICAN INSTITUTE OF STEEL CONSTRUCTION

Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings; as revised June 1949. (For brevity this document is referred to in the Manual as the A.I.S.C. Specification.)

Code of Standard Practice; as revised April 26, 1956.

AMERICAN INSTITUTE OF BOLT, NUT AND RIVET MANUFACTURERS

Tentative Specifications for Cold Riveted Construction; September, 1942.

AMERICAN SOCIETY FOR TESTING MATERIALS

Specifications for Steel for Bridges and Buildings. A.S.T.M. Designation A7-46.

Specifications for Structural Rivet Steel. A.S.T.M. Designation A141-39.

AMERICAN WELDING SOCIETY

Application of and Extracts from Code for Arc and Gas Welding in Building Construction.

UNITED STATES DEPARTMENT OF COMMERCE

Minimum Design Loads in Buildings and other Structures; as sponsored by the National Bureau of Standards and adopted by American Standards Association, A58.1—1945.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION

SPECIFICATION FOR THE DESIGN, FABRICATION AND ERECTION OF STRUCTURAL STEEL FOR BUILDINGS

(RIVETED, BOLTED AND ARC-WELDED CONSTRUCTION)

REVISED JUNE, 1949

CONTENTS

PREFACE

A specification of this type requires for completeness certain general clauses which frequently are provided in the applicable Building Code or General Specification. When so provided, the clauses in such Code or Specification shall of course govern. In the absence of such, the following clauses shall be read into, and shall form a part of, the Specification:

SCOPE.

As used throughout this Specification, the term "structural steel" refers exclusively to those items enumerated in Section 2 of the "Code of Standard Practice for Steel Buildings and Bridges" of the American Institute of Steel Construction, and nothing herein contained shall be interpreted as a recommended practice for steel joists, members formed of flat rolled sheet or strip, light-gage steel construction, skylights, marquises (except structural frame), fire escapes, or other items not specifically enumerated in that Code.

CODE.

In the execution of contracts entered into under this Specification, the "Code of Standard Practice for Steel Buildings and Bridges" of the American Institute of Steel Construction shall apply unless otherwise specified or required.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION

SPECIFICATION FOR THE DESIGN, FABRICATION AND ERECTION OF STRUCTURAL STEEL FOR BUILDINGS

(RIVETED, BOLTED AND ARC-WELDED CONSTRUCTION)

This Specification defines the practice adopted by the American Institute of Steel Construction in the design, fabrication, and erection of structural steel for Buildings.

ADMINISTRATIVE PROVISIONS

SECTION 1. TYPES OF CONSTRUCTION.

Three basic types of design and design assumption are permissible, under the respective conditions stated hereinafter, and each will govern in a specific manner the sizes of members and the types and strength of their connections.

Type 1, commonly designated as "rigid-frame" (continuous, restrained frame), assumes that the end connections of all members in the frame have sufficient rigidity to hold virtually unchanged the original angles between such members and the members to which they connect.

Type 2, commonly designated as "conventional" or "simple" framing (unrestrained, free-ended), assumes that the ends of beams and girders are connected for shear only, and are free to rotate under load.

Type 3, commonly designated as "semi-rigid framing" (partially restrained), assumes that the connections of beams and girders possess a dependable and known moment capacity intermediate in degree between the complete rigidity of Type 1 and the complete flexibility of Type 2.

All connections shall be consistent in their design with the assumptions as to type of construction, as called for on the design drawings.

Type 1 construction is unconditionally permitted under this Specification. It is a necessary condition of this type that the calculated stresses and resulting strains in all members and their connections occur within the elastic range, and that the stresses do not exceed those allowed in Section 15 of this Specification.

Type 2 construction is permitted under this Specification, subject to the stipulations of the following paragraph wherever applicable. Beam-to-column connections with seats for the reactions and with top clip angles for lateral support only, are classed under Type 2.

In tier buildings, designed in general as Type 2 construction, in that the beam-to-column connections other than wind connections are flexible, the distribution of

the wind moments, as between the several joints of the frame, may be made by a recognized empirical method provided that either:

1. The wind connections, designed to resist the assumed wind moments, are adequate to resist the moments induced by the gravity loading and the wind loading, at the increased unit stresses permitted therefor, or,

2. The wind connections, if welded and if designed to resist the assumed wind moments, are so designed that larger moments, induced by the gravity loading under the actual condition of restraint, will be relieved by deformation of the connection material without over-stress in the welds.

Type 3 (semi-rigid) construction will be permitted only upon evidence that the connections to be used are capable of resisting definite moments without overstress of the welds.* The proportioning of main members joined by such connections shall be predicated upon no greater degree of end restraint than the minimum known to be effective by the respective connections.*

Types 2 and 3 construction may necessitate some non-elastic but self-limiting deformation of a structural steel part, but under forces which do not overstress the rivets, bolts or welds.

SECTION 2. DEFINITIONS AND NOMENCLATURE, WELDED CONSTRUCTION

All terms herein relating to welds, welding and gas cutting shall be construed in accordance with the standard "Definitions of Welding Terms and Master Chart of Welding Processes" of the American Welding Society, as amended to date.

SECTION 3. PLANS AND DRAWINGS. STRESS SHEETS.

(a) Plans.

The plans (design drawings) shall show a complete design with sizes, sections, and the relative locations of the various members. Floor levels, column centers, and offsets shall be dimensioned. Plans shall be drawn to a scale large enough to convey the information adequately.

Plans shall indicate the type or types of construction (as defined in Section 1) to be employed; and shall be supplemented by such data as to the assumed loads, and the shears, moments and axial forces to be resisted by all members and their connections, as may be required for the proper preparation of the shop drawings.

(b) Shop Drawings.

Shop drawings, giving complete information necessary for the fabrication of the component parts of the structure, including the location, type, size and extent of all welds, shall be prepared in advance of the actual fabrication. They shall clearly distinguish between shop and field rivets, bolts and welds.

Shop drawings shall be made in conformity with the best modern practice and with due regard to speed and economy in fabrication and erection.

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*The American Institute of Steel Construction expects to publish designs of beam-to-column connections with a statement of the experimentally determined bending resistance thereof.

(c) Notations for Welding.

Note shall be made on the plans and on the shop drawings of those joints or groups of joints in which it is especially important that the welding sequence and technique of welding be carefully controlled to minimize locked-up stresses and distortion.

Weld lengths called for on the plans and on the shop drawings shall be the net effective lengths.

(d) Symbols for Welding.

Welding symbols used on plans and shop drawings shall preferably be the American Welding Society symbols; other adequate welding symbols may be used, provided a complete explanation thereof is shown on the plans or drawings.

SECTION 4. LOADS AND FORCES.

(a) Dead Load.

The dead load to be assumed in design shall consist of the weight of the steelwork and all material fastened thereto or supported thereby.

(b) Live Load.

The live load, and snow load if any, shall be that stipulated by the Code under which the structure is being designed or that required by the conditions involved. In general, the live loads should not be less than those recommended in the "American Standard Building Requirements for Minimum Design Loads in Buildings and Other Structures, A58.1", latest edition.

(c) Wind.

Proper provision shall be made for stresses caused by wind both during erection and after completion of the building. The wind pressure is dependent upon the conditions of exposure and geographical location of the structure. The allowable stresses specified in Paragraphs (d) and (e) of Section 15, are based upon the steel frame being designed to carry a wind pressure of not less than twenty (20) pounds per square foot on the vertical projection of the finished structure.

(d) Other Forces.

Structures in localities subject to earthquakes, hurricanes, and other extraordinary conditions shall be designed with due regard for such conditions.

SECTION 5. WELDING.

(a) Welding.

Welds shall be made only by operators who have been previously qualified by tests, as prescribed in the "Standard Qualification Procedure" of the American Welding Society, to perform the type of work required, except that this provision need not apply to tack welds not later incorporated into finished welds carrying calculated stress.

(b) Rivets and Bolts in Combination with Welds.

In new work, rivets or bolts in combination with welds shall not be considered as sharing the stress, and welds shall be provided to carry the entire stress for which the connection is designed.

In making welded alterations to structures, existing rivets may be utilized for carrying stresses resulting from existing dead loads, and the welding need be adequate only to carry all additional stress.

SECTION 6. TURNED BOLTS.

Turned bolts in close fitting holes as specified in Section 33(e), may be used in shop or field work where it is impracticable to drive satisfactory rivets. The finished shank shall be long enough to provide full bearing, and washers shall be used under the nuts to give full grip when the nuts are turned tight.

The term "turned bolts", as used in this Specification, embraces all bolts regardless of the manufacturing process, which have a tolerance on the nominal diameter of 0 over, .006″ under, and which have "regular semi-finished" heads conforming to "American Standard B18.2—1941" of the American Institute of Bolt, Nut and Rivet Manufacturers.

SECTION 7. ERECTION.

(a) Bracing.

The frame of steel skeleton buildings shall be carried up true and plumb, and temporary bracing shall be introduced wherever necessary to take care of all loads to which the structure may be subjected, including equipment, and the operation of same. Such bracing shall be left in place as long as may be required for safety.

(b) Adequacy of Temporary Connections.

As erection progresses, the work shall be securely bolted up, or welded, to take care of all dead load, wind and erection stresses.

(c) Erection Stresses.

Wherever piles of material, erection equipment or other loads are carried during erection, proper provision shall be made to take care of stresses resulting from the same.

(d) Alignment.

No riveting or welding shall be done until as much of the structure as will be stiffened thereby has been properly aligned.

(e) Field Connections.

All field connections may be made with unfinished bolts, except as follows:

Rivets or welds shall be used for the following connections; except that turned bolts may be used in lieu of rivets as specified in Section 6:

Column splices in all tier structures 200 feet or more in height.

Column splices in tier structures 100 to 200 feet in height, if the least horizontal dimension is less than 40 percent of the height.

Column splices in tier structures less than 100 feet in height, if the least horizontal dimension is less than 25 percent of the height.

Connections of all beams and girders to columns and of any other beams and girders on which the bracing of columns is dependent, in structures over 125 feet in height.

Roof-truss splices and connections of trusses to columns, column splices, column bracing, knee braces and crane supports, in all structures carrying cranes of over 5-ton capacity.

Connections for supports of running machinery, or of other live loads which produce impact or reversal.

Any other connections stipulated on the design plans.

For the purpose of this Section, the height of a tier structure shall be taken as the vertical distance from the curb level to the highest point of the roof beams, in the case of flat roofs, or to the mean height of the gable, in the case of roofs having a rise of more than 2-2/3 in 12. Where the curb level has not been established, or where the structure does not adjoin a street, the mean level of the adjoining land shall be used instead of curb level. Penthouses may be excluded in computing the height of structure.

(f) Field Riveting.

Rivets driven in the field shall be heated and driven with the same care as those driven in the shop.

(g) Field Welding.

All field assembly and welding shall be executed in accordance with the requirements for shop fabrication, excepting such as manifestly apply to shop conditions only.

Any shop paint on surfaces adjacent to joints to be field welded shall be thoroughly removed to expose clean steel for a distance of at least 2 inches on either side of the joint.

(h) Field Painting.

All field rivets, field bolts and field welds, also all serious abrasions to the shop coat, shall be spot painted with the material used for the shop coat, or an equivalent, and all mud and other firmly attached and objectionable foreign materials shall be removed, before general field painting.

Responsibility for this touch-up and cleaning, as well as for general painting, shall be allocated in accordance with accepted local practices and this allocation shall be set forth explicitly in the contract.

SECTION 8. INSPECTION.

(a) General.

Material and workmanship at all times shall be subject to the inspection of experienced engineers representing the purchaser.

(b) Cooperation.

All inspection as far as possible shall be made at the place of manufacture, and the Contractor or Manufacturer shall cooperate with the Inspector permitting access for inspection to all places where work is being done.

(c) Rejections.

Material or workmanship not conforming to the provisions of this Specification may be rejected at any time defects are found during the progress of the work.

(d) Inspection of Welding.

The inspection of welding shall be performed in accordance with the provisions of Section 5 of the "Code for Arc and Gas Welding in Building Construction" of the American Welding Society, as amended to date.

TECHNICAL PROVISIONS

PART I. MATERIAL

SECTION 9. MATERIAL.

(a) Structural Steel.

Structural steel shall conform to the "Standard Specifications for Structural Steel for Bridges and Buildings, Serial Designation A 7" of the American Society for Testing Materials, as amended to date.

(b) Rivet Steel.

Rivet steel shall conform to the "Standard Specifications for Structural Rivet Steel, Serial Designation A141", of the American Society for Testing Materials, as amended to date.

(c) Other Metals.

Cast steel, cast iron and other metals shall conform to the applicable Specifications of the American Society for Testing Materials, as amended to date. Cast Steel for welding shall be of a grade designated as weldable in said Specifications.

(d) Stock Material.

Stock material shall be of a quality equal to that called for by Paragraph (a). Mill test reports shall constitute sufficient record as to the material taken from stock.

Unidentified stock material, if free from surface imperfections, may be used for short sections of minor importance, or for small unimportant details, where the precise physical properties of the material would not affect the strength of the structure.

(e) Filler Metal.

Arc-Welding electrodes shall conform to the requirements of the "Specifications for Iron and Steel Arc-Welding Electrodes" of the American Welding Society, latest edition. Electrodes shall be of Classification Numbers E6010, E6011, E6012, E6013, E6020 or E6030 and shall be suitable for the positions and other conditions of intended use.

With each container of electrodes the manufacturer shall furnish instructions giving recommended voltage and amperage (and polarity if direct current) for all uses and welding positions for which the electrode is suitable.

PART II. LOADS AND STRESSES

SECTION 10. LOADS AND FORCES.

(a) Steel structures shall be designed to sustain the following loads and forces:

1. Dead Load.
2. Live Load.
3. Impact.
4. Wind and other Lateral and Longitudinal Forces.
5. Erection Loads.
6. Other Forces.

(b) Dead Load, Live Load and Other Forces.

The dead load, live load, snow load if any, wind force and any other forces due to extraordinary conditions, to be assumed in design, shall be as specified in Section 4, unless otherwise specified in the applicable Building Code or General Specification.

(c) Impact.

For structures carrying live loads which induce impact or vibration, the assumed live load shall be increased sufficiently to provide for same.

If not otherwise specified, the increase shall be:

For supports of elevators	100 percent
For traveling crane support girders and their connections	25 "
For supports of light machinery, shaft or motor driven, not less than	20 "
For supports of reciprocating machinery or power driven units, not less than	50 "
For threaded hanger rods supporting floors and balconies	33⅓ "

(d) Crane Runway Horizontal Forces.

The lateral force on crane runways to provide for the effect of moving crane trolleys shall, if not otherwise specified, be 20 percent of the sum of the weights of the lifted load and of the crane trolley (but exclusive of other parts of the crane), applied at the top of rail one-half on each side of runway; and shall be considered as acting in either direction normal to the runway rail.

The longitudinal force shall, if not otherwise specified, be taken as 10 percent of the maximum wheel loads of the crane applied at the top of rail.

SECTION 11. MEMBERS SUBJECT TO REVERSAL OF STRESS.

(a) Section of Member.

The sectional area of the portion between connections, of members subject to reversal of stress, need not be increased by reason of the reversal, but shall be sufficient in area and disposition to provide for the maximum compression, and the maximum tension, separately.

(b) Reinforcement at Connections.

The sectional area of members subject to loads (other than wind loads) producing alternating tensile and compressive stresses shall be augmented, at the approach to a connection, by riveting or welding on additional material, so that the augmented section shall comply with the following rule:

To the net total compressive stress, and to the net total tensile stress, add arithmetically 50 percent of the smaller of these two; and proportion the connected material, and the connecting rivets, bolts, pins or welds, for each of the two increased stresses thus separately obtained at the unit stresses prescribed in Section 15 (a).

If the reversal may be expected to occur over 100,000 times in the life of the building, the unit stresses in the connected material and in the connecting rivets, bolts, pins or welds shall not exceed 75 percent of those specified in Section 15 (a). Sharp notches, copes and other sudden changes of cross section shall be particularly avoided in and adjacent to such connections.

SECTION 12. COMBINED STRESSES.

(a) Axial and Bending.

Members subject to both axial and bending stresses shall be so proportioned that the quantity

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \text{ shall not exceed unity, in which}$$

F_a = axial unit stress that would be permitted by this Specification if axial stress only existed.

F_b = bending unit stress that would be permitted by this Specification if bending stress only existed.

f_a = axial unit stress (actual) = axial stress divided by area of member.

f_b = bending unit stress (actual) = bending moment divided by section modulus of member.

(b) Shear with Tension or Compression.

Rivets, bolts and welds subject to shearing and externally applied tensile or compressive forces shall be so proportioned that the combined unit stress will not exceed the unit stress allowed for shear in Section 15 (a).

SECTION 13. COMPOSITE BEAMS.

(a) Definition.

The term "composite beam" shall apply to any rolled or fabricated steel floor beam entirely encased in a poured concrete haunch at least four inches wider, at its narrowest point than the flange of the beam, supporting a concrete slab on each side without openings adjacent to the beam; provided that the top of the beam is at least 1½ inches below the top of the slab and at least 2 inches above the bottom of the slab; provided that a good grade of stone or gravel concrete, with Portland cement, is used; and provided that the concrete haunch has adequate mesh, or other reinforcing steel, throughout its whole depth and across its soffit.

(b) Design Assumptions.

Composite beams may be figured on the assumption that:

1. The steel beam carries unassisted all dead loads prior to the hardening of the concrete, with due regard for any temporary support provided, and
2. The steel and concrete carry by joint action all loads, dead and live, applied after the hardening of the concrete.

(c) Unit Stresses.

The total tensile unit stress in the extreme fibre of the steel beam thus computed shall not exceed 20,000 pounds per square inch. (Section 15 (a)).

The maximum stresses in the concrete, and the ratio of Young's moduli, for steel and concrete, shall be as prescribed by the specifications governing the design of reinforced concrete for the structure.

(d) End Shear.

The web and the end connections of the steel beam shall be designed to carry the total dead and live load, except as this may be reduced by the provision of other proper support.

SECTION 14. EFFECTIVE SPAN LENGTH.

(a) Simple Spans.

Beams, girders and trusses shall ordinarily be designed on the basis of simple spans whose effective length is equal to the distance between centers of gravity of the members to which they deliver their end reactions.

(b) End Restraint.

When designed on the assumption of end restraint full or partial, due to continuous, semi-continuous or cantilever action, the beams, girders and trusses, as well as the sections of the members to which they connect, shall be designed to carry the shears and moments so introduced, as well as all other forces, without exceeding at any point the unit stresses prescribed in Section 15 (a); except that some non-elastic but self-limiting deformation of a part of the connection may be permitted when this is essential to the avoidance of overstressing of a weld.

PART III. UNIT STRESSES

SECTION 15. ALLOWABLE UNIT STRESSES.

Except as provided in this Section under "Bending", under "Wind Only" and under "Wind and Other Forces" and as provided in Section 1, final paragraph, all parts of the structure shall be so proportioned that the unit stress in pounds per square inch shall not exceed the following values:

(a) Structural Steel, Rivets, Bolts and Weld Metal.

(1) Tension.

Structural Steel, net section	20,000
Butt welds, section through throat	20,000
Rivets, on area based on nominal diameter	20,000
Bolts and other threaded parts, on nominal area at root of thread	20,000

(2) Compression.

Columns, gross section

For axially loaded columns with values of l/r not greater than 120 .... $17{,}000 - 0.485\,\frac{l^2}{r^2}$

For axially loaded columns (bracing and other secondary members) with values of l/r greater than 120 .... $\dfrac{18{,}000}{1 + \dfrac{l^2}{18{,}000\, r^2}}$

(for main members, see Section 16 (b)).

in which l is the unbraced length of the column, and r is the corresponding radius of gyration of the section, both in inches.

Plate Girder Stiffeners, gross section	20,000
Webs of Rolled Sections at toe of fillet (Crippling, see Section 26 (h))	24,000
Butt Welds—Section through throat (crushing)	20,000

(3) BENDING.

Tension on extreme fibers of rolled sections, plate girders, and built-up members.

(See Section 26 (a)) 20,000

Compression on extreme fibers of rolled sections plate girders, and built-up members.

With $\frac{ld}{bt}$ not in excess of 600, ... 20,000

With $\frac{ld}{bt}$ in excess of 600, ... $\dfrac{12{,}000{,}000}{\frac{ld}{bt}}$

in which l is the unsupported length and d the depth, of the member; b is the width, and t the thickness, of its compression flange; all in inches; except that l shall be taken as twice the length of the compression flange of a cantilever beam not fully stayed at its outer end against translation or rotation.

Stress on extreme fibers of pins 30,000

Fiber stresses in butt welds, due to bending, shall not exceed the values prescribed for tension and compression, respectively.

Fully continuous beams and girders may be proportioned for negative moments which are maximum at interior points of support, at a unit bending stress 20 percent higher than above stated; provided that the section modulus used over supports shall not be less than that required for the maximum positive moments in the same beam or girder, and provided that the compression flange shall be regarded as unsupported from the support to the point of contraflexure.

For columns proportioned for combined axial and bending stresses, the maximum unit bending stress Fb, Sect. 12 (a) may be taken at 24,000 pounds per square inch, when this stress is induced by the gravity loading of fully or partially restrained beams framing into the columns.

(4) SHEARING.

Rivets 15,000

Pins, and turned bolts in reamed or drilled holes 15,000

Unfinished bolts 10,000

Webs of beams and plate girders, gross section 13,000

Weld Metal

on section through throat of fillet weld, or on faying surface area of plug or slot weld 13,600

on section through throat of butt weld 13,000

(Stress in a fillet weld shall be considered as shear on the throat, for any direction of applied stress. Neither plug nor slot welds shall be assigned any values in resistance to stresses other than shear.)

(5) Bearing.	Double Shear	Single Shear
Rivets	40,000	32,000
Turned bolts in reamed or drilled holes	40,000	32,000
Unfinished bolts	25,000	20,000
Pins	32,000	
Contact Area		
Milled Stiffeners and Other Milled Surfaces	30,000	
Fitted Stiffeners	27,000	
Expansion rollers and rockers (pounds per linear inch)	600d	
in which d is diameter of roller or rocker in inches.		

(b) Cast Steel.

Compression and Bearing, same as for Structural Steel.

Other Unit Stresses, 75 percent of those for Structural Steel.

(c) Masonry Bearing.

Granite	800
Sandstone and Limestone	400
Portland Cement Concrete, unless otherwise specified	600
Hard Brick in Cement Mortar	250

(d) Wind Only.

Members subject only to stresses produced by wind forces may be proportioned for unit stresses 33-1/3 percent greater than those specified for dead and live load stresses. A corresponding increase may be applied to the allowable unit stresses in their connecting rivets, bolts or welds.

(e) Wind and Other Forces.

Members subject to stresses produced by a combination of wind and other loads may be proportioned for unit stresses 33-1/3 percent greater than those specified for dead and live load stresses, provided the section thus required is not less than that required for the combination of dead load, live load, and impact (if any). A corresponding increase may be applied to the allowable unit stresses in their connecting rivets, bolts or welds.

(f) Effective Areas of Weld Metal.

The effective area of butt and fillet welds shall be considered as the effective length of weld times the effective throat thickness.

The effective shearing area of plug and slot welds shall be considered as the nominal cross-sectional area of the hole or slot, in the plane of the faying surface.

The effective area of fillet welds in holes and slots shall be computed as above specified for fillet welds, using for the effective length, the length of center line of the weld through the center of the plane through the throat. However, in the case of overlapping fillets, the effective area shall not exceed the nominal cross-sectional area of the hole or slot, in the plane of the faying surface.

The effective length of a fillet weld shall be the overall length of full-size fillet, including returns.

The effective length of a butt weld shall be the width of the part joined, when ends of the weld are made as specified in Section 33 (m), final paragraph. A transverse

skewed butt weld shall not be assumed in computations to be longer than the width of the joint or piece perpendicular to the direction of stress.

The effective throat thickness of a fillet weld shall be the shortest distance from the root to the face of the diagrammatic weld. (The effective throat thickness of an equal leg 45° fillet weld is 0.707 times the nominal size of the weld.)

The effective throat thickness of a complete-penetration butt weld (i. e., a butt weld conforming to the requirements of Section 33 (m), 2nd paragraph) shall be the thickness of the thinner part joined.

The effective throat thickness of an incomplete-penetration butt weld (i. e., a butt weld not conforming to the requirements of Section 33 (m), 2nd paragraph, but conforming to same Section 3rd paragraph) shall, for design purposes, be considered as 75 percent of the thickness of the thinner part joined.

PART IV. DESIGN

SECTION 16. SLENDERNESS RATIO.

(a) The ratio of unbraced length to least radius of gyration $\frac{l}{r}$ for compression members and for tension members other than rods shall not exceed:

For main compression members	120
For bracing and other secondary members in compression	200
For main tension members	240
For bracing and other secondary members in tension	300

(b) The slenderness of a main compression member may exceed 120, but not 200, provided that it is not ordinarily subject to shock or vibratory loads and provided that its unit stress under full design loading shall not exceed the following fraction of that stipulated under Section 15 (a)(2) for its actual ratio l/r:

$$1.6 - \frac{l}{200\,r}$$

SECTION 17. DEPTH RATIO.

(a) **Simple Spans.**

The depth of beams and girders in floors shall if practicable be not less than 1/24 of the span, and where subject to shocks or vibrations not less than 1/20. If members of less depth are used, the unit stress in bending shall be decreased in the same ratio as the depth is decreased from that above recommended.

The depth of roof purlins shall if practicable be not less than 1/24 of the span, and in no case less than 1/30 of the span, except in the case of corrugated sheeting roofs, with a slope not less than 4¾ in 12.

Beams and girders supporting plastered ceilings shall if practicable be so proportioned that the maximum live load deflection will not exceed 1/360 of the span.

(b) **Restrained and Continuous Spans.**

Minimum depth-ratios for restrained and continuous spans shall if practicable be such that the deflections at critical points will be not greater than those of simple spans of the minimum depth-ratio recommended under Paragraph (a).

(c) **Secondary Tension Members.**

The horizontal projection of the length of bracing and secondary members in tension, other than rods, shall if practicable not exceed 90 times the depth.

SECTION 18. MINIMUM THICKNESS OF MATERIAL.*

(a) General.

The minimum thicknesses required for protection against crippling, buckling, and shear are prescribed in Paragraphs (b) and (c) of this section and in Paragraph (b) of Section 26, respectively. Those stipulations assume that the material is straight and true as erected, within the limits prescribed in Section 33 (q), and is not reduced by corrosion.

No further stipulations as to minimum thickness shall apply to steelwork exposed to conditions no more seriously corroding than an indoor atmosphere controlled for human comfort, subject always to the requirements of Section 34 (a).

The following stipulations (1) and (2) as to minimum thickness shall apply to exterior steelwork enclosed in a non-impervious envelope or exposed to frequent rain or snow, and to interior steelwork subject to atmospheric exposure more corrosive than that mentioned in the preceding paragraph:

(1) Columns, studs, lintels, girders and beams; exterior trusses, exterior bracing members; one-fourth inch minimum.

(2) Purlins, girts, trusses and bracing members sheltered from direct exposure to rain and snow; three-sixteenths inch minimum.

The controlling thickness of rolled shapes, for the purposes of stipulations (1) and (2), shall be taken as the mean thickness of their flanges, regardless of web thickness.

Steelwork exposed to industrial fumes or vapor shall be given special protection as required in the judgment of the Engineer.

(b) Projecting Elements Under Compression.

Projecting elements of members subjected to axial compression or compression due to bending shall have ratios of width to thickness not greater than the following:

Single angle struts; 12.

Double-angle struts; angles or plates projecting from girders, columns or other compression members; compression flanges of beams; stiffeners on plate girders; flanges or stems of tees; 16.

The width of plates shall be taken from the free edge to the first row of rivets or welds; the width of legs of angles, channels and zees, and of the stems of tees, shall be taken as the full nominal dimension; the width of flanges of beams and tees shall be taken as one-half the full nominal width. The thickness of a sloping flange shall be measured halfway between a free edge and the corresponding face of the web.

When a projecting element exceeds the width-to-thickness ratio prescribed in the preceding paragraph, but would conform to same and would satisfy the stress requirements with a portion of its width considered as removed, the member will be considered acceptable without the actual removal of the excess width.

(c) Compression Members.

In compression members the unsupported width of web, cover or diaphragm plates between the nearest lines of rivets or welds, or between the roots of the flanges in case of rolled sections, shall not exceed 40 times the thickness.

When the unsupported width exceeds this limit, but a portion of its width no greater than 40 times the thickness would satisfy the stress requirements, the member will be considered acceptable.

The unsupported width of cover plates perforated with a succession of access holes, only the least net width across holes being assumed available to resist compression, may exceed 40, but shall not exceed 50, times the thickness.

*Revised June 23, 1949

SECTION 19. GROSS AND NET SECTIONS.

(a) Definitions.

The gross section of a member at any point shall be determined by summing the products of the thickness and the gross width of each element as measured normal to the axis of the member. The net section shall be determined by substituting for the gross width the net width computed in accordance with paragraphs (c) to (g) of this Section.

(b) Application.

Unless otherwise specified, tension members shall be designed on the basis of net section. Columns shall be designed on the basis of gross section. Beams and girders shall be designed in accordance with Section 26 (a).

In determining the net section across plug or slot welds the weld metal shall not be considered as adding to the net area.

(c) Net Width.

In the case of a chain of holes extending across a part in any diagonal or zigzag line, the net width of the part shall be obtained by deducting from the gross width the sum of the diameters of all the holes in the chain, and adding, for each gage space in the chain, the quantity

$$\frac{s^2}{4g} \quad \text{where}$$

s = longitudinal spacing (pitch) in inches of any two successive holes.
g = transverse spacing (gage) in inches of the same two holes.

The critical net section of the part is obtained from that chain which gives the least net width.

(d) Angles.

For angles, the gross width shall be the sum of the widths of the legs less the thickness. The gage for holes in opposite legs shall be the sum of the gages from back of angle less the thickness.

(e) Splice Members.

For splice members, the thickness considered shall be only that part of the thickness of the member which has been developed by rivets or welds beyond the section considered.

(f) Size of Holes.

In computing net area the diameter of a rivet hole shall be taken as $\frac{1}{8}$ inch greater than the nominal diameter of the rivet.

(g) Pin Holes.

In pin connected tension members, other than forged eyebars, the net section across the pin hole, transverse to the axis of the member, shall be not less than 135 percent, and the net section beyond the pin hole, parallel with the axis of the member, not less than 90 percent, of the net section of the body of the member.

In all pin-connected riveted members the net width across the pin hole, transverse to the axis of the member, shall not exceed 8 times the thickness of the member at the pin, unless lateral buckling is prevented.

SECTION 20. EXPANSION.

(a) Transverse Expansion.

No provision for transverse expansion in structures need be made in wall bearing spans of 50 feet and under. Wall bearing spans of over 50 feet and up to and including 100 feet shall slide on smooth surfaces at one end. Wall bearing spans of over 100 feet shall have expansion rollers or rockers at one end. Expansion ends shall be secured against lateral movement; fixed ends against movement in any direction.

(b) Longitudinal Expansion.

Provision shall be made for longitudinal expansion of the structure. All expansion provisions shall be figured for 100 degrees F. variation in temperature and for a coefficient of expansion of 0.0000065 per degree per unit of length. Expansion joints in buildings having masonry wall enclosures shall be so spaced as to inhibit visible cracking of the walls.

SECTION 21. CONNECTIONS.

(a) Minimum Connections.

Connections carrying calculated stresses, except for lacing, sag bars, and girts, shall be designed for not less than 10,000 pounds, if welded; or if riveted or bolted, shall have no fewer than two rivets or two bolts.

(b) Eccentric Connections.

Members meeting at a point shall have their gravity axes meet at a point if practicable; if not, provision shall be made for bending stresses due to the eccentricity.

(c) Placement of Rivets and Welds.

The rivets or welds at the ends of any member transmitting stresses into that member should preferably have their centers of gravity on the gravity axis of the member; otherwise, provision shall be made for the effect of the resulting eccentricity. Pins may be so placed as to counteract the effect of bending due to dead load.

(d) Unrestrained Members.

Except as otherwise indicated by the designer, all connections of beams, girders or trusses shall be designed as flexible, and may ordinarily be proportioned for the reaction shears only. If, however, the eccentricity of the connection is excessive, provision shall be made for the resulting moment.

Flexible beam connections shall permit the ends of the beam to rotate sufficiently to accommodate its deflection by providing for a horizontal displacement of the top flange as determined as follows:

$e = .007d$ if the beam is designed for full uniform load and for live load deflection not exceeding 1/360th of the span (see Section 17 (a));

or $e = \dfrac{f\,L}{3{,}625{,}000}$ if the beam is designed for full uniform load producing the unit stress f at mid span;

where e = the horizontal displacement between the top and bottom of the beam at its end, in inches.

f = the flexural unit stress in the beam at mid span; p.s.i.

d = the depth of the beam, in inches.

L = the span of the beam, in feet.

(e) Restrained Members.

When beams, girders or trusses are subject both to reaction shear and end moment, due to full or partial end restraint, or to continuous or cantilever construction, their connections shall conform to the requirements of Section 12 (b).

(f) Fillers.

In riveted construction, when rivets carrying computed stress pass through fillers, the fillers shall be extended beyond the connected member and the extension secured by enough rivets to distribute the total stress in the member uniformly over the combined sections of the member and filler.

Fillers under the stiffeners on riveted plate girders, at end bearings or at points of concentrated loads, shall be secured by sufficient rivets to prevent excessive bending and bearing stresses.

In welded construction, when a filler is used between two parts connected in shear, there shall be sufficient welding to transfer the shearing stress from one part to the filler and from the filler to the other part. Fillers of less than ¼ inch thickness shall not be used to transfer stress, but shall be trimmed flush with the welded edges of the stress-carrying element and the sizes of the welds along the edges shall be increased over the required sizes by an amount equal to the thickness of the filler.

(g) Connections of Tension and Compression Members in Trusses.

The connections at ends of tension or compression members in trusses shall either develop the full effective strength of the material, or they shall develop the strength required by the total stresses; but in no case shall such strength developed be less than 50 percent of the effective strength of the material connected.

(h) Milled Joints in Compression Members.

Where compression members are in full-milled bearing on base plates, and where full-milled tier-building columns are spliced, there shall be sufficient rivets, bolts or welds to hold all parts securely in place.

Where other compression members are spliced by full-milled bearing, the splice material and its riveting or welding shall be arranged to hold all parts in line and shall be proportioned for 50 percent of the computed stress.

All the foregoing joints shall be proportioned to resist any tension that would be developed by specified wind forces acting in conjunction with 75 percent of the calculated dead load stress and no live load, if this condition will produce more tension than with full dead load and live load applied.

(i) Combinations of Welds.

If two or more of the general types of weld (butt, fillet, plug, slot) are combined in a single joint, the effective capacity of each shall be separately computed with reference to the axis of the group, in order to determine the allowable capacity of the combination.

SECTION 22. RIVETS AND BOLTS.

(a) Diameter.

In proportioning and spacing rivets, the nominal diameter of the undriven rivet shall be used.

(b) Effective Bearing Area.

The effective bearing area of pins, bolts, and rivets shall be the diameter multiplied by the length in bearing; except that for countersunk rivets half the depth of the countersink shall be deducted.

(c) Double and Single Shear Bearing.

Only that portion of a rivet or bolt shall be considered in double shear bearing, which lies between two portions which share the reaction therefrom. The remainder of the rivet or bolt shall be considered in single shear bearing.

(d) Long Grips.

Rivets which carry calculated stress, and the grip of which exceeds five diameters, shall have their number increased 1 percent for each additional 1/16 inch in the rivet grip. Special care shall be used in heating and driving such rivets.

(e) Unfinished Bolts.

If unfinished bolts are provided with washers under nuts, and have unthreaded shanks extending completely through the joined parts, the shearing and bearing values elsewhere prescribed for unfinished bolts may be increased one-eighth.

SECTION 23. SPACING OF RIVETS.

(a) Minimum Pitch.

The minimum distance between centers of rivet holes shall preferably be not less than three times the diameter of the rivet.

(b) Maximum Pitch in Compression Members.

The maximum pitch in the line of stress of compression members composed of plates and shapes shall not exceed 16 times the thickness of the thinnest outside plate or shape, nor 20 times the thickness of the thinnest enclosed plate or shape, with a maximum of 12 inches.

At right angles to the direction of stress, the distance between lines of rivets shall not exceed 32 times the thickness of the thinnest plate where there is more than one ply. For angles in built-up sections with two gage lines, with rivets staggered, the maximum pitch in the line of stress in each gage line shall not exceed 24 times the thickness of the thinnest plate with a maximum of 18 inches.

(c) End Pitch in Compression Members.

The pitch of rivets at the ends of built compression members shall not exceed four diameters of the rivets for a length equal to 1½ times the maximum width of the member.

(d) Two-Angle Members.

In tension members composed of two angles, a pitch of 3′ 6″ will be allowed, and in compression members, 2′ 0″, but the ratio l/r for each angle between rivets shall be not more than ¾ of that for the whole member.

(e) Minimum Edge Distance.

The minimum distance from the center of any punched rivet hole to any edge shall be that given in Table I.

TABLE I

Rivet Diameter, Inches	Minimum Edge Distance (Inches) for Punched Holes		
	In Sheared Edge	In Rolled Edge of Plates	In Rolled Edge of Structural Shapes
½	1	⅞	¾*
⅝	1⅛	1	⅞*
¾	1¼	1⅛	1 *
⅞	1½	1¼	1⅛*
1	1¾	1½	1¼*
1⅛	2	1¾	1½*
1¼	2¼	2	1¾*

*May be decreased ⅛ inch when holes are near end of beam.

(f) Minimum Edge Distance in Line of Stress.

The distance from the center of any rivet under computed stress, and that end or other boundary of the connected member toward which the pressure of the rivet is directed, shall be not less than the shearing area of the rivet shank (single or double shear respectively) divided by the plate thickness.

This end distance may however be decreased in such proportion as the stress per rivet is less than that permitted under Section 15 (a); and the requirement may be disregarded in case the rivet in question is one of three or more in a line parallel to the direction of stress.

(g) Maximum Edge Distance.

The maximum distance from the center of any rivet to the near edge shall be 12 times the thickness of the plate, but shall not exceed 6 inches.

SECTION 24. WELDS.

(a) Types of Welds.

Butt, fillet, plug or slot welds, or a combination of these types, may be used in making joints and joining component parts.

(b) Qualification of Weld Details.

The details of all joints (including for butt welds the groove form, root face, root spacing, etc. etc.) to be employed under this specification without qualification shall comply with all of the requirements for joints which are accepted without qualification test under the "Code for Arc and Gas Welding in Building Construction" of the American Welding Society. No joint form not included in the foregoing shall be employed until it shall have been qualified to the satisfaction of the Engineer in accordance with the "Standard Qualification Procedure" of the American Welding Society.

(c) Minimum Size of Fillet Welds.

The relation between weld size and the maximum thickness of material on which various sizes of fillet welds may be used shall, where practicable, conform to the following table:

Size of Fillet Inches	Maximum Thickness of Part Inches
$\frac{3}{16}$	$\frac{1}{2}$
$\frac{1}{4}$	$\frac{3}{4}$
$\frac{5}{16}$	$1\frac{1}{4}$
$\frac{3}{8}$	2
$\frac{1}{2}$	6
$\frac{5}{8}$	Over 6

(d) Maximum Effective Size of Fillet Welds.

The maximum size of a fillet weld that may be assumed in the design of a connection shall be such that the stresses in the adjacent base material do not exceed the values allowed in Section 15 (a).

The maximum size fillet weld applied to a nominally square edge of plate or shape shall be $\frac{1}{16}$ inch less than the nominal thickness of the edge, and the size of fillet weld used along the toe of an angle or the rounded edge of a flange shall not exceed three-fourths the nominal thickness of the angle leg or three-fourths the nominal edge thickness of the flange; except that when required by the design conditions and specially designated on the drawings, fillet welds equal in size to the edge of a plate or rolled section may be used, provided that the weld is built out in such a manner as to insure full throat thickness, full fusion area, and no injury to the base metal that will reduce its thickness adjacent to the weld.

(e) Length of Fillet Welds.

The minimum effective length of a strength fillet weld shall be not less than four times the nominal size, or else the size of the weld shall be considered not to exceed one-fourth of its effective length.

The effective length of any segment of intermittent fillet welding shall be not less than four times the weld size with a minimum of $1\frac{1}{2}$ inches.

If longitudinal fillet welds are used alone in end connections, the length of each fillet weld shall be not less than the perpendicular distance between them.

(f) End Returns of Fillet Welds.

Side or end fillet welds terminating at ends or sides, respectively, of parts or members shall, wherever practicable, be returned continuously around the corners for a distance not less than twice the nominal size of the weld. This provision shall apply to side and top fillet welds connecting brackets beam seats and similar connections, at the tension side of such connections, on the plane about which bending moments are computed. End returns shall be indicated on the design and detail drawings.

(g) Plug and Slot Welds.

Plug or slot welds, or fillet welds in holes or slots, may be used in plates not more than one inch thick, where subjected principally to shearing stresses or where needed to prevent buckling of lapped parts.

The diameter of the holes for plug welds and the width of slot welds shall be not less than the thickness of the part containing the hole or slot, plus $\frac{5}{16}$ inch rounded to the next greater odd sixteenth. The diameter of plug welds and the width of slot welds shall not be greater than 3 times the thickness of the weld metal.

The maximum length of slot welds shall not exceed 10 times the thickness of the part containing the slot.

SECTION 25. SPACING OF WELDS.

(a) Longitudinal Fillet Welds.

The transverse spacing of longitudinal fillet welds used in end connections shall not exceed 8 inches, unless the design otherwise prevents excessive transverse bending in the connection.

(b) Intermittent Fillet Welds.

Intermittent fillet welds may be used to transfer calculated stress across a joint or faying surfaces when the strength required is less than that developed by a continuous fillet weld of the smallest practical size. The clear spacing in the direction of stress, between the effective lengths of such segments at the edges of plates and at the unsupported edges of rolled shapes carrying calculated stress, shall not exceed the following number times the thickness of the thinner part joined: for compression, 16; for tension, 24; and shall in no case be more than 12 inches. The effective length of longitudinal fillet welds at the ends of built-up members shall be not less than the width of the component part joined.

(c) Lap Joints.

The minimum width of laps, on lap joints, shall be five times the thickness of the thinner part joined and not less than 1 inch. Lap joints joining plates or bars subjected to axial stress shall be fillet welded along the edge of both lapped parts except where deflection of the lapped parts is sufficiently restrained to prevent opening of the joint under maximum loading.

(d) Slot Welds.

The clear distance from the edge of a slot to the adjacent edge of the slotted part, and the clear distance between adjacent slots, measured in a direction perpendicular to that of the main stress, shall be not less than five times the thickness of the slotted part nor less than twice the width of the slot.

(e) Stitch Welds.

If two or more plates or rolled shapes are used to build up a member, sufficient stitch welding (of the fillet, plug or slot type) to make the parts act in unision shall be provided as follows, except where transfer of calculated stress between the parts joined requires closer spacing.

1. For plates, the longitudinal clear spacing between stitch welds shall not exceed the provisions of paragraph (b) of this section and the transverse spacing shall not exceed 32 times the thickness of the thinner plate joined.
2. For members composed of two or more rolled shapes, in contact one with another, the longitudinal spacing of stitch welds shall not exceed 24 inches or the limits prescribed in (3).
3. For members composed of rolled shapes, separated one from the other by a gusset plate, the component parts shall be stitched together at intervals such that the critical ratio l/r, for each component, between stitching, shall not exceed three-fourths the critical ratio for the whole member.

SECTION 26. PLATE GIRDERS AND ROLLED BEAMS.

(a) Proportioning.

Riveted and welded plate girders, cover-plated beams, and rolled beams shall in general be proportioned by the moment of inertia of the gross section. No deduction shall be made for standard shop or field rivet holes in either flange; except that in special cases where the reduction of the area of either flange by such rivet holes, calculated in accordance with the provisions of Section 19, exceeds 15 percent of the gross flange area, the excess shall be deducted. If such members contain other holes, as for bolts, pins, countersunk rivets, or plug or slot welds, the full deduction for such holes shall be made. The deductions thus applicable to either flange shall be made also for the opposite flange if the corresponding holes are there present.

(b) Web.

Plate girder webs shall have a thickness of not less than 1/170 of the unsupported distance between flanges.

(c) Flanges.

The thickness of outstanding parts of flanges shall conform to the requirements of Section 18 (b).

Each flange of welded plate girders should in general consist of a single plate rather than two or more plates superimposed. The single plate may comprise a series of shorter plates, laid end to end and butt welded at their junctions.

Unstiffened cover plates on riveted girders shall not extend more than 16 times the thickness of the thinnest outside plate beyond the outer row of rivets connecting them to the angles. The total cross-sectional area of cover plates of riveted girders shall not exceed 70 percent of the total flange area.

If the girder is subjected to substantial fluctuations in loading, stiffeners, lateral plates or other appurtenant material shall not be welded to the tension flange, except at points where the maximum flange stress is less than half the allowable.

(d) Flange Development.

Rivets and welds connecting flange to web, or cover plates to flange, shall be proportioned to resist the maximum horizontal shear at the plane in question, resulting from the bending forces on the girder. Additionally, rivets and welds connecting flange to web shall be proportioned to transmit any loads applied directly to the flange.

(e) Stiffeners.

Bearing stiffeners shall be placed in pairs on the webs of plate girders at unframed ends and at points of concentrated loads. Such stiffeners shall have a close bearing against the loaded flanges, and shall extend as closely as possible to the edge of the flange plates or flange angles. They shall be designed as columns subject to the provisions of Section 15 (a); assuming the column section to comprise the pair of stiffeners and a centrally located strip of the web equal to not more than 25 times its thickness at interior stiffeners or a strip equal to not more than 12 times its thickness when the stiffeners are located at the end of the web. The column length shall be taken as not less than ¾ of the length of the stiffeners in computing the ratio l/r. Only that portion of the stiffener outside of the angle fillet or the flange-to-web welds shall be considered effective in bearing. Angle bearing stiffeners shall not be crimped.

If $\frac{h}{t}$ is equal to or greater than 70, intermediate stiffeners shall be required at all points where v exceeds $\frac{64,000,000}{(h/t)^2}$, in which

h = the clear depth between flanges, in inches.

t = the thickness of the web, in inches.

v = the greatest unit shear in the panel, in pounds per square inch, under any condition of complete or partial loading.

The clear distance between intermediate stiffeners, when stiffeners are required by the foregoing, shall not exceed 84 inches or that given by the formula

$$d = \frac{11,000\ t}{\sqrt{v}} \quad \text{where}$$

d = the clear distance between stiffeners, in inches.

Intermediate stiffeners may be applied in pairs, one on each side of the web, or if preferred may alternate on opposite side of the web.

Intermediate angle stiffeners may be crimped over the flange angles. Intermediate stiffeners employed to stay the web plate against buckling, and not for the transfer of concentrated loads from flange to web, shall be of a section not less than that required by the formula

$$I_s = 0.00000016\ H^4, \text{ in which}$$

H = total depth of web.

I_s = moment of inertia of the stiffeners or stiffener (figured with a common axis at the centerline of web for stiffeners in pairs and with the axis at the interface between stiffener and web for single stiffeners).

Rivets connecting stiffeners to the girder web shall be spaced not over 8 times their diameter, or more closely if so required in order to transmit the stress due to concentrated loads. If intermittent fillet welds are used, their spacing shall conform to the provisions of Section 25 (b).

(f) Splices.

Web splices in plate girders and in beams shall be proportioned to transmit the full shearing and bending stresses in the web at the point of splice. Web splices in welded girders shall preferably be complete penetration butt welds.

If the flanges are spliced, the splices shall either develop the full effective strength of the material or they shall develop the strength required by the total stresses, but in no case shall the strength developed be less than 50 percent of the effective strength of the material spliced, nor shall butt-welded joints be only partially welded.

(g) Horizontal Forces.

The flanges of plate girders supporting cranes or other moving loads shall be proportioned to resist the horizontal forces produced by such loads. (See Section 10 (d)).

(h) Web Crippling of Beams.

Rolled beams shall be so proportioned that the compressive stress at the web toe of the fillets, resulting from concentrated loads not supported by bearing stiffeners,

shall not exceed the value of 24,000 pounds per square inch allowed in Section 15 (a). The governing formulas shall be

$$\text{For interior loads} \quad \frac{R}{t\,(N + 2k)} = \text{not over } 24{,}000$$

$$\text{For end-reactions} \quad \frac{R}{t\,(N + k)} = \text{not over } 24{,}000$$

where

R = concentrated interior load or end reaction, in pounds.

t = thickness of web, in inches.

N = length of bearing, in inches.

k = distance from outer face of flange to web toe of fillet, in inches.

SECTION 27. SEPARATORS.

(a) Separators.

Where two or more rolled beams or channels are used to form a girder, they shall be connected together at intervals of not more than 5 feet. Through-bolts and separators may be used provided that in beams having a depth of 12 inches or more, no fewer than 2 bolts shall be used with each separator. When concentrated loads are carried from one beam to the other, or distributed between the beams, diaphragms shall be used, designed with sufficient stiffness to distribute the load. Where beams are exposed, they shall be sealed against corrosion of interior surfaces, or spaced sufficiently far apart to permit cleaning and painting.

SECTION 28. TIE PLATES.

(a) Compression Members.

The open sides of compression members built up from plates or shapes shall be provided with lacing having tie plates at each end, and at intermediate points if the lacing is interrupted. Tie plates shall be as near the ends as practicable. In main members carrying calculated stress the end tie plates shall have a length of not less than the distance between the lines of rivets or welds connecting them to the segments of the member, and intermediate ones of not less than one-half of this distance. The thickness of tie plates shall be not less than one-fiftieth of the distance between the lines of rivets or welds connecting them to the segments of the members. In riveted construction, the rivet pitch in tie plates shall be not more than six diameters and the tie plates shall be connected to each segment by at least three rivets. In welded construction, the welding on each line connecting a tie plate shall aggregate not less than one-third the length of the plate.

(b) Tension Members.

Tie plates shall be used to secure the parts of tension members built up from plates or shapes. They shall have a length not less than two-thirds of the length specified for tie plates in compression members. Otherwise they shall conform to the requirements of Section 28 (a).

SECTION 29. LACING.

(a) Spacing.

Lacing bars (which term comprehends for the purposes of this Section flat bars, angles, channels or other shapes employed as lacing) of compression members shall be so spaced that the ratio l/r of the flange included between their connections shall be not over ¾ of the critical ratio for the member as a whole.

(b) Proportioning.

Lacing bars shall be proportioned to resist a shearing stress normal to the axis of the member equal to two percent of the total compressive stress in the member.

Lacing bars shall preferably be arranged in single system, for which the ratio l/r shall not exceed 140. For double lacing this ratio shall not exceed 200. Double lacing bars shall be joined at their intersections.

In determining the section required for lacing bars, the compression formula shall be used, l being taken as the unsupported length of the lacing bar between rivets or welds connecting it to the segments, for single lacing, and 70 percent of that distance for double lacing.

(c) Inclination.

The inclination of lacing bars to the axis of the member shall preferably be not less than 60 degrees for single lacing and 45 degrees for double lacing. When the distance between the lines of rivets or welds in the flanges is more than 15 inches, the lacing shall preferably be double or be made of angles.

(d) Perforated Cover Plates.

The function of tie plates and lacing may be assumed to be performed by the material in continuous cover plates perforated with a succession of access holes, the net width of which plates across holes is assumed available to resist axial stress, provided that: the ratio of length (in direction of stress) to width of hole shall not exceed 2; the clear distance between holes in the direction of stress shall be not less than the transverse distance between nearest lines of connecting rivets or welds; and the periphery of the holes at all points shall have a minimum radius of 1½ inches.

SECTION 30. CAMBER.

(a) Shown on Plans.

Cambering, if any, of trusses, beams or girders shall be called for on the design plans.

(b) Trusses and Girders.

Trusses of 80 feet or greater span should generally be cambered for approximately the dead load deflection. Crane girders of 75 feet or greater span should generally be cambered for approximately the dead and half live load deflection.

(c) Beams.

Specified camber for rolled beams over 15 inches in depth, shall be only that offered as cold cambering at the mill.

(d) Camber for Other Trades.

If camber is required in order to bring a loaded member into proper relation with the work of other trades, as for the attachment of runs of sash, the requirements shall be set forth on the plans and on the detail drawings.

(e) Erection.

Required camber of trusses shall be shown on the erection diagram. If camber involves the erection of any member under a straining force, this shall be noted on the erection diagram.

SECTION 31. COLUMN BASES.

(a) Loads.

Proper provision shall be made to transfer the column loads, and moments if any, to the footings and foundations.

(b) Alignment.

Column bases shall be set level and to correct elevation with full bearing on the masonry.

(c) Finishing.

Column bases shall be finished to accord with the following requirements:

1. Rolled steel bearing plates, 2 inches or less in thickness, may be used without planing, provided a satisfactory contact bearing is obtained; rolled steel bearing plates, over 2 inches but not over 4 inches in thickness, may be straightened by pressing; or, if presses are not available, by planing on all bearing surfaces, to obtain a satisfactory contact bearing; rolled steel bearing plates, over 4 inches in thickness, shall be planed on all bearing surfaces (except as noted under 3).
2. Column bases other than rolled steel bearing plates shall be planed on all bearing surfaces (except as noted under 3).
3. The bottom surfaces of bearing plates and column bases which rest on masonry foundations and are grouted to insure full bearing contact need not be planed.

SECTION 32. ANCHOR BOLTS.

Anchor Bolts.

Anchor bolts shall be designed to provide resistance to all conditions of tension and shear at the bases of columns, including the net tensile components of any bending moments which may result from fixation or partial fixation of columns.

PART V. FABRICATION

SECTION 33. WORKMANSHIP.

(a) General.

All workmanship shall be equal to the best practice in modern structural shops.

(b) Straightening.

All material shall be clean and straight. If straightening or flattening is necessary, it shall be done by a process and in a manner that will not injure the material. Sharp kinks or bends shall be cause for rejection.

(c) Gas Cutting.

The use of a cutting torch is permissible if the metal being cut is not carrying substantial stress during the operation. Gas-cut edges which will be subjected to substantial tensile stress shall be cut by a mechanically-guided torch, or if hand cut shall be carefully examined and any nicks removed. The radii of re-entrant gas-cut fillets shall be as large as practicable, but never less than 1 inch. Edges and grooves may be prepared for welding by gas cutting, as defined in Section 33 (h).

(d) Planing of Edges.

Planing or finishing of sheared edges of plates or shapes, or of edges gas-cut with a mechanically guided torch, will not be required unless specifically called for on the drawings, or included in a stipulated edge preparation for welding.

(e) Riveted Construction—Holes.

Holes for rivets or unfinished bolts shall be 1/16 inch larger than the nominal diameter of the rivet or bolt. If the thickness of the material is not greater than the nominal diameter of the rivet or bolt plus 1/8 inch, the holes may be punched. If the thickness of the material is greater than the nominal diameter of the rivet or bolt plus 1/8 inch, the holes shall be either drilled from the solid, or sub-punched and reamed. The die for all sub-punched holes, and the drill for all sub-drilled holes, shall be at least 1/16 inch smaller than the nominal diameter of the rivet or bolt.

Drifting to enlarge unfair holes shall not be permitted. Holes that must be enlarged to admit the rivets shall be reamed. Poor matching of holes shall be cause for rejection.

Holes for turned bolts shall be drilled or reamed truly cylindrical and not more than 1/50 inch larger than the external diameter of the bolt. Drilling or reaming for turned bolts shall be done after the parts to be connected are assembled; except that if such drilling or reaming after assembly is impracticable, it may be done through steel templets with hardened bushings.

(f) Riveted Construction—Assembling.

All parts of riveted members shall be well pinned or bolted and rigidly held together while riveting. Drifting done during assembling shall not distort the metal or enlarge the holes.

(g) Riveting.

Rivets shall be driven by power riveters, of either compression or manually-operated type, employing pneumatic, hydraulic or electric power. After driving they shall be tight and their heads shall be in full contact with the surface.

Rivets shall ordinarily be hot-driven, in which case their finished heads shall be of approximately hemispherical shape and shall be of uniform size throughout the work for the same size rivet, full, neatly finished and concentric with the holes. Hot-driven rivets shall be heated uniformly to a temperature not exceeding 1950° F; they shall not be driven after their temperature has fallen below 1000° F.

Rivets may be driven cold if approved measures are taken to prevent distortion of the riveted material. The requirements for hot-driven rivets shall apply except as modified in the "Tentative Specifications for Cold-Driven Rivets" of the American Institute of Bolt, Nut and Rivet Manufacturers.

(h) Welded Construction—Preparation of Material.

Surfaces to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material, except that mill scale which withstands vigorous wire

brushing, may remain. A light film of linseed oil may be disregarded. Joint surfaces shall be free from fins and tears. Preparation of edges by gas cutting shall, wherever practicable, be done with a mechanically guided torch.

(k) Welded Construction—Assembling.

Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated more than 3/16 inch. If the separation is 1/16 inch or greater, the size of the fillet welds shall be increased by the amount of the separation. The separation between faying surfaces of lap joints shall not exceed 1/16 inch. The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting.

Abutting parts to be butt welded shall be carefully aligned. Misalignments greater than 1/8 inch shall be corrected and, in making the correction, the parts shall not be drawn into a sharper slope than two degrees (7/16 inch in 12 inches).

The work shall be positioned for flat welding whenever practicable.

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member.

(l) Welded Construction—Temperatures.

No welding shall be done when the temperature of the base metal is lower than 0° F. At temperatures between 32° F. and 0° F., the surface of all areas within three inches of the point where a weld is to be started, shall be heated to a temperature at least warm to the hand before welding is started.

When welds are being made in parts thicker than 1½ inches, the temperature of the base material adjacent to the welding shall be at least 70° F.

(m) Welding.

The technique of welding employed, the appearance and quality of welds made, and the methods used in correcting defective work shall conform to the "Code for Arc and Gas Welding in Building Construction" of the American Welding Society, Section 4—Workmanship.

All complete-penetration butt welds, except when produced with the aid of backing material or welded in the flat position from both sides in square-edge material not more than 5/16 inch thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged or chipped out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire intended cross section. Butt welds made with the use of a backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips may be removed by means of gas cutting, after welding is completed, provided no injury is done to the base and weld metal and the weld surface is left flush or slightly convex, with full throat thickness.

Incomplete-penetration butt welds shall be made with as nearly complete penetration and internal soundness as the formation of the joint and the method of welding will permit. (See Section 15 (f), final paragraph).

To insure soundness, the ends of butt welds that carry stresses approaching the maximum allowable working stress shall be extended past the edges of the parts joined, by means of short extension bars providing a similar joint preparation and having a width not less than the thickness of the thicker part joined. Where the metal is not more than $\frac{3}{4}$ inch in thickness, the extension bars may be omitted if the ends of the butt weld are chipped or cut down to solid metal and side welds are applied to fill out the ends to the same reinforcement as the faces of the weld. If extension bars are removed upon completion of the weld, the ends of the weld shall be left smooth and flush with the edges of the abutting parts.

(n) **Welded Construction—Peening.**

Where required, multiple-layer welds may be peened with light blows from a power hammer, using an elongated round-nose tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling, flaking or cold working of weld and base metal from over-peening.

(o) **Finishing.**

Compression joints depending upon contact bearing shall have the bearing surfaces machined to a common plane after the members are completed.

(p) **Lacing Bars.**

The ends of lacing bars shall be neat and free from burrs.

(q) **Tolerances.**

Finished members shall be true to line and free from twists, bends and open joints.

Compression members may have a lateral variation not greater than 1/1000 of the axial length between points which are to be laterally supported.

A variation of $\frac{1}{32}$ inch is permissible in the overall length of members with both ends milled.

Members without milled ends which are to be framed to other steel parts of the structure may have a variation from the detailed length not greater than $\frac{1}{16}$ inch for members 30 feet or less in length, and not greater than $\frac{1}{8}$ inch for members over 30 feet in length.

(r) **Castings.**

Steel castings shall be annealed.

SECTION 34. SHOP PAINTING.

(a) **Shop Coat.**

After inspection and approval and before leaving the shop, all steel work shall be thoroughly cleaned, by effective means, of all loose mill scale, rust, spatter, slag or flux deposit, oil, dirt and other foreign matter. Except where encased in concrete,

and excepting edges and surface areas adjacent to edges, to be field welded, all steel work shall be given one coat of approved metal protection, applied thoroughly and evenly and well worked into the joints and other open spaces. All paint shall be applied to dry surfaces.

(b) Inaccessible Parts.

Parts inaccessible after assembly shall be given two coats of shop paint, preferably of different colors.

(c) Contact Surfaces.

Contact surfaces shall be cleaned, by effective means, before assembly, but not painted.

(d) Finished Surfaces.

Machine-finished surfaces shall be protected against corrosion by a suitable coating.

(e) Surfaces to be Field Welded.

Surfaces which are to be welded after erection shall where practicable not receive a shop coat of paint. If painted, such paint shall be removed before field welding, for a distance of at least 2 inches on either side of the joint.

SECTION 35. ADMINISTRATIVE PROVISIONS.

All of the Administrative Provisions contained in this Specification, preceding the Technical Provisions, are to be complied with under any contract invoking the Technical Provisions, unless and except as otherwise provided in the applicable Building Code or General Specifications.

FOREWORD

The Code of Standard Practice for Steel Buildings and Bridges was completely revised on June 26, 1952 by the American Institute of Steel Construction, Inc.

On April 26, 1956, certain minor revisions in Section 2 and Section 6 were adopted. These revisions are included in the present printing of the Code.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION

CODE OF STANDARD PRACTICE FOR STEEL BUILDINGS AND BRIDGES

ADOPTED 1924
REVISED APRIL 26, 1956

Since steel was first used for structural purposes, and concurrently with the development of the structural steel industry, fabricators, erectors, owners, architects, engineers and contractors have developed certain practices relating to the design, fabrication and erection of structural steel which have become standard. While these standards are generally known, it is the purpose of the American Institute of Steel Construction in publishing these standards to make them available for ready reference by all those concerned with the use of structural steel in construction.

The standards herein described have been compiled as the result of studies made by engineers and other members of the staff of the American Institute of Steel Construction and are set forth in reasonable detail in the following resume.

SECTION 1. GENERAL.

(a) Standard Specifications.

In the absence of other instructions, the provisions of the following standard specifications, as revised to date, govern the design, fabrication and erection of structural steel:

For buildings and similar structures:

Specification for the Design, Fabrication and Erection of Structural Steel for Buildings of the American Institute of Steel Construction;

For bridges:

Standard Specifications for Highway Bridges of American Association of State Highway Officials;

Specifications for Steel Railway Bridges of American Railway Engineering Association;

Specifications for Welded Highway and Railway Bridges of American Welding Society.

(b) Plans and Specifications for Bidding.

In order to insure adequate and complete bids, plans and specifications accompanying the invitation to bid show:

(1) A complete design indicating the character of the work to be performed and giving sizes, sections and the relative location of various members, floor levels, column centers and offsets, with sufficient dimensions to convey adequately the quantity and nature of the required structural steel, and

(2) Wind bracing and other special details, in sufficient detail regarding rivets, welds and construction so that they may be readily understood and supplied.

Plans are made to a scale not less than 1/8 inch to the foot and the more complex information is furnished to adequate scale.

When the owner* provides the design, plans and specifications the fabricator and erector are not responsible for the suitability, adequacy or legality of the design; nor is the fabricator responsible for the practicability or safety of erection if the structure is erected by others. If the owner desires the fabricator or erector to prepare the design, plans and specifications or to assume any responsibility for the suitability, adequacy or legality of the design, he clearly states his requirements either in the invitation to bid or on such plans and specifications which accompany it.

(c) Patented Devices.

Fabricators assume that all necessary patent rights have been obtained and that they (the fabricators) will be fully protected in the use of patented designs, devices or parts shown on the plans which the owner supplies.

SECTION 2. DEFINITION OF STRUCTURAL STEEL.

The term "structural steel" comprehends only the following categories of parts:

- Anchors for structural steel;
- Bases of steel or iron;
- Beams, purlins, girts;
- Bearing plates for structural steel;
- Bearing shoes for bridges;
- Bracing;
- Brackets;
- Bridge pins;
- Bridge railings of steel;
- Columns of steel, iron, or pipe, or cement filled pipe;
- Counterweight boxes for bridges;
- Crane rails and stops;
- Door frames constituting part of the steel framing;
- Expansion joints connected to the steel frame;
- Floor plates (checkered or smooth) connected to the steel frame;
- Girders of steel;
- Grillage beams and girders of steel;
- Hangers of structural steel, if attached to the structural steel framing and shown on the framing plans;
- Lintels shown on the framing plans or otherwise enumerated or scheduled;
- Marquees (structural steel frame only);
- Monorail beams of standard structural shapes;
- Separators, angles, tees, clips and other detail fittings essential to the structural steel frame;
- Suspended ceiling supports of structural shapes 3 inches or greater in depth;
- Shop rivets, permanent shop bolts, bolts required to assemble parts for shipment and shop welds;
- Struts;
- Tie, hanger and sag rods forming part of the structural steel frame; and
- Trusses.

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*This term is used to designate not only the owner of the proposed structure, but also the architect, engineer, general contractor, public authority, or other designated representatives of the owner.

Field Connection Material.

When the fabricator erects the structural steel, the fabricator supplies all materials required for temporary and for permanent connection of the component parts of the structural steel.

When the erection of the structural steel is performed by someone other than the fabricator, the fabricator furnishes:

1. Rivets of suitable size and in sufficient quantity for all field connections of steel to steel which are designated as riveted field connections, plus 10 per cent thereof to cover waste;
2. Common bolts of suitable size and in sufficient quantity for all field connections of steel to steel which are specified to be permanently bolted, plus 5% thereof to cover waste. Turned bolts, high-strength bolts, other special types of bolts, and washers, are furnished (allowing 2% to cover waste) only when specified in the invitation to bid.

Unless specified in the invitation to bid or the specifications which accompany it, welding electrodes, shims, *thin bearing plates used in lieu of shims to provide an exact level grade ready to receive steel columns or girders with bases fabricated as an integral part of the member*, fitting-up bolts and drift pins required for field connections are not furnished by the fabricator, when the erection is performed by others.*

The term "structural steel" does not include steel, iron or other items which are required for the assembly or erection of materials supplied by trades other than structural steel fabricators or erectors, even though such materials are shown on the plans as fastened to the structural steel.

SECTION 3. CALCULATION OF WEIGHTS.

If bids are requested or submitted at a price per pound of fabricated structural steel delivered or erected, rather than on a lump sum job basis, the actual weighing of materials is often impracticable and inaccurate. It is desirable to calculate such weights according to the formula commonly used by fabricators, erectors and owners. While this formula does not produce actual weights, it is customarily used by fabricators and erectors in bidding on a price per pound basis because it obviates the necessity of meticulous and involved calculations or additional shop work that entail substantial expense. Fabricators and erectors use this formula to calculate weights of fabricated structural steel for all purposes, unless the invitation to bid or the owner's plans or specifications require the use of scale weights or some other method of calculation.

The standard formula or method of calculating weights of fabricated structural steel is as follows:

(a) The weight of steel is assumed to be 0.2833 of a pound per cubic inch and the weight of cast iron is assumed to be 0.2604 of a pound per cubic inch.

(b) Weights of shapes, plates, bars, castings, rivets, bolts and weld metal are calculated on the basis of detailed shop drawings and shop bills of material showing actual dimensions of materials used as follows:

1. Weight is calculated on the basis of rectangular dimensions for all plates and ordered overall lengths for all structural shapes from which the required material is cut, without deductions for copes, clips, sheared edges,

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* This paragraph revised April 26, 1956

punchings, borings, milling or planing. When parts can be economically cut in multiples from material of larger dimension, the weight is calculated on the basis of the dimensions of the material from which the parts are cut.

2. To the nominal theoretical weight of all universal mill and sheared plates and slabs there is added one-half the allowance for variation or overweight in accordance with the applicable table in the A.S.T.M. specifications.

3. To the nominal theoretical weight of checkered plates there is added the allowance for overweight in accordance with the published weights of the manufacturer of such plates.

4. The calculated weights of castings are determined from the detail drawings of the pieces. An allowance for standard fillets for such pieces and an average over-run of 10% are added.

(c) The weight of shop rivets is calculated according to the following table:

Diameter of Rivet	Calculated Weight per 100 Rivets
½ inch	20 pounds
⅝ "	30 "
¾ "	50 "
⅞ "	100 "
1 "	150 "
1⅛ "	250 "
1¼ "	325 "

The weights of field rivets, shop and field bolts, nuts and washers, are taken at their actual weights.

(d) The following percentages of the calculated weight of material so protected are added for painting or galvanizing:

For each shop coat of paint	½ of 1%
For each coat of oil	¼ of 1%
For galvanizing by hot dipping	3½%

(e) The weight of shop welds and of field welds in work erected by the fabricator, is calculated on the basis of the gross weight of electrode required to lay the weld as follows:

1. For standard equal-leg fillet welds:

Specified Weld Size (Inches)	Gross Weight of Electrode (Pounds per Foot of Weld*)	
	Continuous	Intermittent**
⅛	.08	.09
3/16	.15	.17
¼	.25	.28
5/16	.36	.40
⅜	.50	.55
½	.83	.91
⅝	1.25	1.40
¾	1.75	1.95
⅞	2.35	2.60
1	3.00	3.30

*Net length as called for on the drawings, exclusive of starting and stopping ends.

**Weld length less than 32 times the specified size.

2. For unequal-leg fillet welds, the weight in the above table corresponding to the small leg is multiplied by the ratio of the longer leg to the smaller leg.

3. For all groove welds, the weight of electrode is calculated by adding 100% to the weight based upon the net theoretical weld cross section and length. The net theoretical volume of a square groove weld with zero root opening is calculated as if 1/32" open.

SECTION 4. DRAWINGS AND SPECIFICATIONS.

(a) To enable the fabricator and erector to proceed properly and expeditiously with the work, the owner furnishes as soon as possible a survey of the building site or the lot lines and a set of complete drawings consistent with the original bidding plans and specifications. These show:

1. The design of the bridge or of the structural steel framework and definitely locate all openings, levels, etc.; also,

2. All materials to be furnished by the fabricator and give such information as may be necessary for the preparation and completion of shop drawings by the fabricator.

(b) In case of discrepancies between drawings and specifications for buildings, the specifications govern. In the case of discrepancies between drawings and specifications for bridges, the drawings govern. In case of discrepancies between scale dimensions on the drawings and figures written on them, the figures govern.

(c) When shop drawings are made by the fabricator, prints thereof are submitted to the owner for his examination and approval. In order for the fabricator to commence shop work, the owner must return one set of prints to the fabricator (customarily within five days) with a notation of the owner's outright approval or approval subject to corrections as noted. It is usual practice for the fabricator to make the corrections and to furnish one set of corrected prints to the owner.

(d) While shop drawings prepared by the fabricator and approved by the owner are deemed to represent the correct interpretation of the work to be done, the fabricator is not relieved of responsibility for accuracy of detailed dimensions shown thereon.

(e) When the shop drawings are furnished by the owner, he must deliver them to the fabricator in time to permit the fabrication to proceed in an orderly manner in accordance with the prescribed time schedule. The owner prepares these shop drawings, insofar as practicable in accordance with the shop and drafting room standards of the fabricator.

The owner is responsible for the completeness and accuracy of shop drawings so furnished.

SECTION 5. STOCK MATERIALS.

(a) Many fabricators maintain stocks of steel products for use in their fabricating operations. Such materials as are taken from stock by the fabricator for use for structural purposes must be of a quality at least equal to that required by the specifications of the American Society for Testing Materials applicable to the classi-

fications covering the intended use. Mill test reports are accepted in the trade as sufficient record of the quality of materials carried in stock by the fabricator.

The fabricator checks and retains the mill test reports covering the materials he purchases for stock, but, because it is obviously impracticable to do so, he does not maintain records such as would identify individual pieces of stock material against individual mill test reports. Such records are not required if the fabricator purchases for stock under established specifications as to grade and quality and the purchases can be checked against mill test reports.

(b) It is common practice for the fabricator to use steel materials from his stock in his fabricating operations whenever he desires to do so, instead of ordering items from the mill for the specific use. Stock materials purchased under no particular specifications or under specifications less rigid than those mentioned above, or stock materials which have not been subject to mill or other recognized test reports, are not used without the express approval of the owner and then only under rigid inspection, except that such material may be used for small unimportant details where the quality of the material could not affect the strength of the structure.

SECTION 6. INSPECTION AND DELIVERY.

(a) Test of Materials.

Mill test reports are furnished by the fabricator upon request of the owner, provided such request is incorporated in the invitation to bid or otherwise made in writing prior to the time the fabricator places his mill orders with the mill so that he can, in turn, request them of the mill. If other tests are desired, the owner so specifies in the invitation to bid. The fabricator customarily makes no tests of steel materials and the owner must rely on such additional tests of quality as he orders the fabricator to have made. If tests of materials by others than the mills are desired the owner should arrange for such tests through the fabricator.

(b) Inspection.

If the owner wishes an inspection of the steel by someone other than the fabricator's own inspectors, he reserves the right to do so in his invitation to bid or the accompanying specifications. Arrangements may be made with the fabricator for inspection of materials at the fabricating shop by the owner's inspectors.

(c) Shop Painting.

Prior to painting, the fabricator cleans the steel of rust, loose mill scale, dirt and other foreign material by means of wire brushing. Unless specified, the fabricator does not sandblast, flame clean, or pickle the material prior to painting.

The shop coat of paint is a priming coat intended to protect the steel for a temporary period of weathering only. Fabricators do not assume responsibility for the deterioration that may result from extended exposure to the elements.*

(d) Delivery of Materials.

The fabricator will deliver the fabricated structural steel to the job site in such sequence as will permit the most efficient and economical performance of his own work. If the owner wishes to prescribe or control the sequence of delivery of materials, he reserves such right in his invitation to bid or the specifications which accompany it.

* This paragraph revised April 26, 1956

The quantities of material shown by the shipping statement are customarily accepted by the owner, fabricator and erector as correct. Accordingly, if any shortage is claimed, the owner should immediately notify the carrier and the fabricator in order that the claim may be investigated.

(e) Marking and Shipping of Materials.

Erection marks are painted on the structural steel members. Weights are marked on members weighing more than ten tons.

Rivets and bolts are commonly shipped in separate containers according to length and diameter and loose nuts and washers are shipped in separate containers according to sizes. Pins and other small parts, and packages of rivets, bolts, nuts and washers are usually shipped in boxes, crates, kegs or barrels. A list and description of the material will usually appear on the outside of each closed container.

Long girders are so loaded and marked that they may be delivered at the site in position for handling without turning. Instructions for such delivery should be given to the receiving carrier.

Anchor bolts, washers, and other anchorage or grillage materials to be built into the masonry should be shipped so that they will be on hand when needed. To make this possible, the owner should give the fabricator sufficient time to fabricate and ship such materials before they are needed.

SECTION 7. ERECTION.

(a) Method of Erection.

If the owner wishes to control the method and sequence of erection, he so specifies in the invitation to bid or the specifications that accompany it. Otherwise the erector will proceed according to the most efficient and economical method available to him consistent with the plans and specifications and such information as may be furnished to him prior to the execution of the contract.

(b) Foundations, Piers and Abutments.

The invitation to bid, or the specifications which accompany it, should specify the time when all foundations, piers and abutments will be ready, free from obstruction, and accessible to the erector. Unless the owner specifies to the contrary in inviting bids, the fabricator and erector will bid on a basis of being able to start erection at a designated time without interference or delay caused by the owner or by other contractors. The accurate location, strength and suitability of all foundations, piers and abutments is the sole responsibility of the owner.

(c) Building Lines and Bench Marks.

The owner must accurately locate building lines and bench marks at the site of the structure and furnish the fabricator a plan containing all such information.

(d) Anchor Bolts.

All anchor or foundation bolts and other connections between the structural steel and the work of other trades are located and set by the owner. In order to avoid unnecessary expense, the owner must assume responsibility for the accurate and complete performance of such work in time so as not to delay or interfere with the erection of the structural steel.

(e) Steel and Cast Iron Bases and Bearing Plates.

All steel grillage, rolled steel bearing plates, cast iron or steel bases which are too heavy to be set without a derrick or crane are set and wedged or shimmed by the steel erector, to grade or level lines which are determined and fixed by the owner, who in turn grouts all such parts in place. All other loose bearing plates are set to grade and are grouted by the owner. Before grouting, the owner checks the grades and levels of the parts to be grouted, and is responsible for the accuracy of the same. For steel columns or girders with bases fabricated as an integral part of the member, the foundation is finished to exact grade, level and ready to receive the steel work.

(f) Loose Lintels.

Unless otherwise specified in the invitation to bid or the specifications which accompany it, the owner sets, without assistance from the erector of the structural steel, such loose lintels, shelf angles, and other pieces not attached to the structural steel as are required by the plans for spanning over openings in the masonry, which can be placed only as the masonry progresses.

(g) Working Space.

The owner affords the erector convenient and sufficient space at the site for his derricks, cranes, and other necessary equipment. When the structure does not occupy the full available site, the owner provides sufficient storage space to enable the erector to operate at maximum practicable speed.

(h) Plumbing Up.

In the erecting of structural steel for structures other than bridges, the individual pieces are plumbed and leveled by the erector, and are considered plumb or level if the error does not exceed 1 to 500, except that, in the case of exterior columns and columns adjacent to elevator shafts in multiple-story buildings, they are considered plumb if the error does not exceed 1 to 1000.

The owner, by whatever agencies he may elect, immediately upon completion by the erector, determines whether the work is plumb, level and properly guyed, and whether all lintels attached without provision for adjustment are in their proper location. In the event the owner finds otherwise, he immediately notifies the erector of any matters requiring correction. The responsibility of the erector in this connection ceases when he shall have once located, plumbed, leveled, guyed and braced the structural steel to the satisfaction of the owner.

The temporary guys, braces and falsework or cribbing remain the property of the erector and he will remove them immediately upon completion of his work unless other arrangements are made. The owner removes, and returns to the erector in good condition, any guys and braces temporarily left in place under such an arrangement.

(i) Correction of Errors when Material is not Erected by the Fabricator.

Corrections of minor misfits and a reasonable amount of cutting and reaming are considered a part of erection. Any error in shop work which prevents the proper assembling and fitting of parts by the moderate use of drift pins, or a moderate amount of reaming, chipping or cutting, should be immediately reported to the fabricator, so that he may either correct the error or approve the method of correction that is to be used.

(j) Field Assembling.

The size of assembled pieces of structural steel may be limited by the permissible weight and clearance dimensions of transportation. Unless otherwise directed by the owner, the fabricator will provide for such field connections as will, in his opinion, require the least amount of field work.

(k) Cutting, Drilling and Patching.

The fabricator or erector does not cut, drill or patch the work of others or his own work to accommodate other trades. If the owner desires that cutting, drilling, or patching of the structural steel be performed by the fabricator or erector for the accommodation of other trades he so specifies at the time the invitation to bid is issued.

(l) Temporary Floors for Buildings.

It is customary for the owner to provide planking and to cover such floors as may be required by municipal or state laws, excepting the floor upon which the erecting derricks are located; the steel erector will cover this floor for his working purposes, moving his planking as the work progresses. If other arrangements are desired, the owner's invitation to bid and specifications should so specify.

(m) Field Painting.

The erector does not paint field bolt heads and nuts, field rivet heads, field welds, or touch up abrasions in the shop coat, or perform any other field painting unless specified in the owner's specifications accompanying the invitation to bid.

(n) Final Cleaning Up.

Upon completion of erection and before final acceptance, the erector removes all falsework, rubbish and temporary buildings furnished by him.

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COLD RIVETED CONSTRUCTION

INTRODUCTION

Cold-driven structural rivets of ½-inch size and larger, have been used in many types of structures, both in this country and in Canada. Large, high-strength, alloy-steel rivets have been successfully driven cold in certain types of armament subjected to severe ballistic shock. The principal advantages expected, by its proponents, to be gained by cold driving are the superior filling of rivet holes, the increased rivet stiffness due to the cold working of the rivet metal, and the economies resulting from the elimination of heating.

There being no general specifications available to guide and protect the users, the American Institute of Steel Construction in 1940, at the request of the American Institute of Bolt, Nut and Rivet Manufacturers, appointed a special subcommittee of its Committee on Technical Research to investigate the use of cold-driven rivets and prepare a specification covering their use.

The following specifications were accordingly developed, were adopted by the American Institute of Bolt, Nut and Rivet Manufacturers, and were offered to the fabricating industry in tentative form for a period of trial. Criticisms, and suggestions for improvement, are invited.

AMERICAN INSTITUTE OF BOLT, NUT AND RIVET MANUFACTURERS

TENTATIVE SPECIFICATIONS

FOR

COLD RIVETED CONSTRUCTION

(RIVETS ½ INCH DIAMETER AND LARGER)

SEPTEMBER, 1942

1. GENERAL

Cold riveted construction shall conform to the present specifications for riveted work and to the following requirements.

2. RIVETS

(a) Grade.

Rivets shall be of the same grade as used for hot riveting, such as ASTM A141 or A31, except that hot made rivets shall not be quenched, and cold made rivets shall be annealed.

(b) Heads.

Button, high-button, or any other American Standard type of manufactured head may be used. If approved by the customer, flat heads may be used having a diameter 1½ times and a minimum height of head ⅜ times the nominal diameter of the rivet.

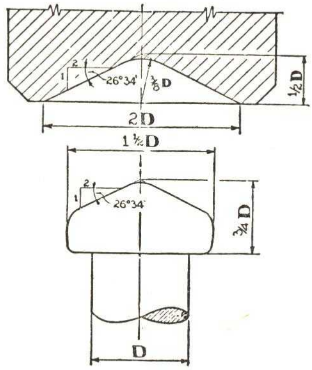
(c) Points.

Rivet points shall be free from shearing cracks, and shall be reasonably square to prevent bending of the rivet shank during driving.

3. FABRICATION

(a) Driven Head.

The driven heads of rivets shall be flat head or a modified cone, or other types within the range of cold riveting as agreed upon between the user and the supplier. The diameter of the flat head shall be approximately 1½ times and the minimum height of head ¼ times the nominal diameter of the rivet; the modified cone head shall conform to the following:



(b) Riveting Pressure.

The pressure shall be properly controlled and sufficient to form the specified head, but not of an amount that will warp or buckle the work.

(c) Driving Die.

The die for driving the heads shall not restrict the free transverse flow of metal at the edge of the head.

(d) Holes.

Diameter of hole shall be larger than nominal diameter of rivet by not more than: 1/32″ for ½″ to ⅝″ diameter, inclusive; 1/16″ above ⅝″.

AMERICAN SOCIETY FOR TESTING MATERIALS

STANDARD SPECIFICATIONS FOR STEEL FOR BRIDGES AND BUILDINGS

A. S. T. M. DESIGNATION: A 7-46

These specifications are in effect a revision and consolidation of, and replace the former Standard Specifications for Steel for Bridges (A 7 – 36) and for Steel for Buildings (A 9 – 36). These latter specifications were originally adopted in 1901 and continued as standard with various revisions until their combination with Specifications A 7 in 1939.

Scope.

1. These specifications cover carbon-steel shapes, plates and bars of structural quality for use in the construction of bridges and buildings and for general structural purposes.

Castings, Rivet Steel, Forgings, Sheet, Strip.

2. For use with steel purchased under these specifications, the following standards of the American Society for Testing Materials shall apply:

(a) **Steel Castings.**

The Tentative Specifications for Mild to Medium Strength Carbon-Steel Castings for General Application (A.S.T.M. Designation: A 27) shall govern the purchase of steel castings for bridges and buildings. Unless otherwise specified, grade B-1 castings, fully annealed, with a minimum yield point of 33,000 psi., shall be used.

(b) **Structural Rivet Steel.**

Unless otherwise specified, the Standard Specifications for Structural Rivet Steel (A. S. T. M. Designation: A 141) shall govern the purchase of rivets.

(c) **Forgings.**

The Standard Specifications for Carbon-Steel Forgings for General Industrial Use (A. S. T. M. Designation: A 235), and for Alloy-Steel Forgings for General Industrial Use (A. S. T. M. Designation: A 237) may also be used for forgings.

(d) **Sheet and Strip.**

Hot rolled sheets and strip specified to this specification shall be furnished unless otherwise specified, to Grade C, minimum tensile strength 55,000 psi., of the Tentative Specifications for Light Gage Structural Quality Flat Hot-Rolled Carbon Steel (A. S. T. M. Designation: A 245).

Structural Bolts.

3. Unless otherwise specified, bolts to be employed in permanent connections between parts fabricated of steel purchased under these specifications shall be subject to the requirements of Section 9 (a) for minimum tensile strength (to be taken on the area at root of thread) and to the requirements of Section 10 for cold bend (to be taken on the unthreaded portion of the bolt), and shall be exempt from further requirements.

A. I. S. I. STANDARD CLASSIFICATION BY SIZE OF FLAT-ROLLED CARBON STEEL

Widths, Inches	Thicknesses, Inch							
	0.2500 and thicker	0.2499 to 0.2031	0.2030 to 0.1875	0.1874 to 0.0568	0.0567 to 0.0344	0.0343 to 0.0255	0.0254 to 0.0142	0.0141 and thinner
To 3½ incl.	Bar	Bar	Strip	Strip	Strip	Strip	Sheet	Sheet
Over 3½ to 6 incl.	Bar	Bar	Strip	Strip	Strip	Sheet	Sheet	Sheet
" 6 to 12 "	Plate	Strip	Strip	Strip	Sheet	Sheet	Sheet	Sheet
" 12 to 32 "	Plate	Sheet	Sheet	Sheet	Sheet	Sheet	Sheet	Blk. Plate
" 32 to 48 "	Plate	Sheet	Sheet	Sheet	Sheet	Sheet	Sheet	Sheet
" 48	Plate	Plate	Plate	Sheet	Sheet	Sheet	Sheet	——

Rolled Base Plates.

4. Rolled base plates over 2 in. in thickness for bearing purposes shall be open-hearth or electric-furnace steel containing 0.20 to 0.35 per cent carbon. The chemical composition shall also conform to the requirements specified in Section 6. A sufficient discard shall be made from each ingot to secure sound plates. Physical tests shall not be required for this material.

Process.

5. **(a)** The steel, except as may be specified in Paragraph (b), shall be made by either or both of the following processes: open-hearth or electric-furnace.

(b) Steel for plates and shapes 7/16 in. and under in thickness, and bars (other than those for rivets) 7/16 in. and under in thickness or diameter, intended for use in buildings and other structures subject to static loads only, may be made by the acid-bessemer process, unless otherwise specified.

Chemical Composition.

6. The steel shall conform to the following requirements as to chemical composition:

Phosphorus, max., per cent:	
Open-hearth or electric-furnace:	
Acid	0.06
Basic	0.04
Acid-bessemer	0.10
Sulfur, max., per cent (open-hearth or electric-furnace)	0.05
Copper, when copper steel is specified, min., per cent	0.20

Ladle Analysis.

7. **(a)** An analysis of each melt of open-hearth or electric-furnace steel shall be made to determine the percentages of carbon, manganese, phosphorus, and sulfur; also copper when copper steel is specified.

(b) A carbon determination, and a copper determination when copper steel is specified, shall be made of each melt of bessemer steel, and determinations for manganese, phosphorus, and sulfur representing the average of the melts applied for each 8-hr. period.

(c) The analyses prescribed in Paragraphs (a) and (b) shall be made by the manufacturer from test ingots taken during the pouring of the melts. The chemical composition thus determined shall be reported to the purchaser or his representative, and the percentages of phosphorus and sulfur, also copper when copper steel is specified, shall conform to the requirements specified in Section 6.

Check Analysis.

8. An analysis may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 6 by more than 25 per cent.

Tensile Properties.

9. **(a)** The material, except as specified in Sections 3 and 4 and Paragraph (b) of this section, shall conform to the following requirements as to tensile properties:

	Plates, Shapes, and Bars
Tensile strength, psi	60 000 to 72 000
Yield point, min., psi	0.5 tens. str.
but in no case less than	33 000
Elongation in 8 in., min., per cent	$\frac{1\,500\,000^{a}}{\text{Tens. str.}}$
Elongation in 2 in., min., per cent	22

a See Paragraphs (d) and (e).

(**b**) Plates $\frac{3}{16}$ in. in thickness, shapes less than 1 sq. in. in cross-section, and bars, other than flats, less than $\frac{1}{2}$ in. in thickness or diameter need not be subjected to tension tests.

(**c**) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

(**d**) For material over $\frac{3}{4}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Paragraph (a) of 0.25 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness or diameter above $\frac{3}{4}$ in. to a minimum of 18 per cent for plates, shapes, and bars.

(**e**) For material under $\frac{5}{16}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Paragraph (a) of 2.00 per cent shall be made for each decrease of $\frac{1}{32}$ in. of the specified thickness or diameter below $\frac{5}{16}$ in.

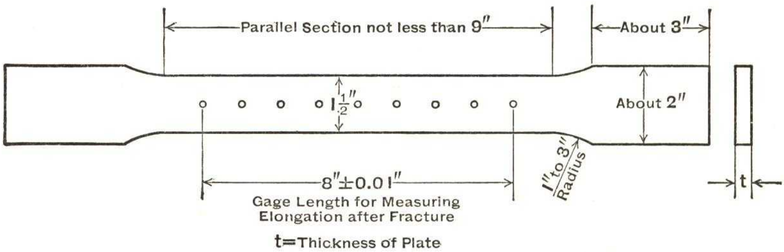


FIG. 1.—Standard 8-in. Gage Length Test Specimen.

Bending Properties.

10. The bend test specimen shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion to an inside diameter which shall have the following relation to the thickness of the specimen:

Thickness of Material	Ratio of Bend Diameter to Thickness of Specimen Plates, Shapes and Bars
$\frac{3}{4}$ in. and under	$\frac{1}{2}$
Over $\frac{3}{4}$ to 1 in., incl.	1
Over 1 to $1\frac{1}{2}$ in., incl.	$1\frac{1}{2}$
Over $1\frac{1}{2}$ to 2 in., incl.	$2\frac{1}{2}$
Over 2 in.	3

Test Specimens.

11. (**a**) Test specimens shall be prepared for testing from the material in its rolled or forged condition, except as specified in Paragraph (b).

(**b**) Test specimens for annealed material shall be prepared from the material as annealed for use or from a short length of a full section from the same melt similarly treated.

(c) Test specimens shall be taken longitudinally and, except as specified in Paragraphs (e), (f), and (g), shall be the full thickness or section of material as rolled.

(d) Test specimens for plates, shapes, and flats may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

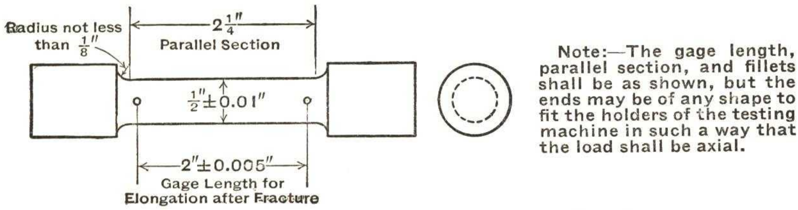


FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(e) Tension test specimens for material over 1½ in. in thickness or diameter, except pins and rollers, may be machined to a thickness or diameter of at least ¾ in. for a length of at least 9 in., or they may conform to the dimensions shown in Fig. 2.

(f) Bend test specimens for material over 1½ in. in thickness or diameter, except pins and rollers, may be machined to a thickness or diameter of at least ¾ in. or to 1 by ½ in. in section.

(g) Tension test specimens for pins and rollers shall conform to the dimensions shown in Fig. 2, and bend test specimens shall be 1 by ½ in. in section.

(h) Test specimens for pins and rollers shall be taken so that the axis is 1 in. from the surface.

(i) The sides of the bend test specimens may have the corners rounded to a radius not over ⅟₁₆ in.

Number of Tests.

12. (a) Two tension and two bend tests shall be made from each melt, unless the finished material from a melt is less than 30 tons when one tension test and one bend test will be sufficient. If, however, material from one melt differs ⅜ in. or more in thickness, one tension test and one bend test shall be made from both the thickest and the thinnest material rolled regardless of the weight represented.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 9 and any part of the fracture is more than ¾ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

TABLE I. PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

Specified Thickness, Inches	Permissible Excess in Average Weight of Lots for Widths Given, in Inches, Expressed in Percentage of Nominal Weights										
	48 and under	Over 48 to 60, excl.	60 to 72, excl.	72 to 84, excl.	84 to 96, excl.	96 to 108, excl.	108 to 120, excl.	120 to 132, excl.	132 to 144, excl.	144 to 168, excl.	168 and over
$\frac{3}{16}$ to $\frac{1}{4}$, excl.	....	8	9	10	12	14	16	18			
$\frac{1}{4}$ to $\frac{5}{16}$, "	6	7	8	9	10	12	14	16	19		
$\frac{5}{16}$ to $\frac{3}{8}$, "	5	6	7	8	9	10	12	14	17	18	
$\frac{3}{8}$ to $\frac{7}{16}$, "	4.5	5	6	7	8	9	10	12	15	16	18
$\frac{7}{16}$ to $\frac{1}{2}$, "	4	4.5	5	6	7	8	9	10	13	14	16
$\frac{1}{2}$ to $\frac{5}{8}$, "	4	4	4.5	5	6	7	8	9	11	12	14
$\frac{5}{8}$ to $\frac{3}{4}$, "	4	4	4	4.5	5	6	7	8	9	10	12
$\frac{3}{4}$ to 1, "	3.5	4	4	4	4.5	5	6	7	8	9	11
1 to 2, incl.	3.5	3.5	4	4	4	4.5	5	6	7	8	9

NOTE.—Permissible variations in weight for individual plates shall be one and one-third times the amounts prescribed in this table.

Permissible Variations in Weight and Thickness.

13. **(a)** One cubic inch of rolled steel is assumed to weigh 0.2833 lb. The cross-sectional area or weight of each structural-size shape shall not vary more than 2.5 per cent from the theoretical or specified amounts. The thickness or weights of rectangular sheared mill plates and of universal mill plates shall conform to the requirements of Paragraphs (b), (c), (d), or (e).

(b) Plates, when Ordered to Thickness.—No plate shall vary more than 0.01 in. under the thickness specified.

(c) The overweight of each lot[1] of plates in each shipment shall not exceed the amounts prescribed in Table I.

TABLE II. PERMISSIBLE VARIATIONS OF PLATES ORDERED TO WEIGHT.

Specified Weight, lb. per sq. ft.	Permissible Variations in Average Weight of Lots for Widths Given, in Inches, Expressed in Percentage of Ordered Weights (Weight per Square Foot)																					
	48 or under		Over 48 to 60, excl.		60 to 72, excl.		72 to 84, excl.		84 to 96, excl.		96 to 108, excl.		108 to 120, excl.		120 to 132, excl.		132 to 144, excl.		144 to 168, excl.		168 or over	
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under
7.65 to 10, excl.	----	----	4.5	3	5	3	5.5	3	6	3	----	----	----	----	----	----	----	----	----	----	----	----
10 to 12.5, excl.	4	3	4.5	3	5	3	5.5	3	6	3	6.5	3	7	3	8	3	9	3	----	----	----	----
12.5 to 15, excl.	4	3	4	3	4.5	3	5	3	5.5	3	5.5	3	6	3	7.5	3	8	3	----	----	----	----
15 to 17.5, excl.	3.5	3	3.5	3	4	3	4.5	3	5	3	5	3	5.5	3	6	3	7	3	9	3	10	3
17.5 to 20, excl.	3.5	2.5	3.5	2.5	3.5	3	4	3	4.5	3	4.5	3	5	3	5.5	3	6	3	8	3	9	3
20 to 25, excl.	3.5	2.5	3.5	2.5	3.5	3	3.5	3	4	3	4	3	4.5	3	5	3	5.5	3	7	3	8	3
25 to 30, excl.	3	2.5	3.5	2.5	3.5	2.5	3.5	3	3.5	3	3.5	2.5	4	3	4.5	3	5	3	6.5	3	7	3
30 to 40, excl.	3	2	3	2	3	2	3	2	3.5	2	3.5	2	3.5	2.5	4	3	4.5	3	6	3	6.5	3
40 to 81.6, incl.	2.5	2	3	2	3	2	3	2	3.5	2	3.5	2	3	2.5	3.5	3	4	3	5.5	3	6	3

NOTE.—Permissible variations in weight for individual plates shall be one and one-third times the amounts prescribed in this table.

[1]The term "lot" as applied to Table I means all the plates of each group width and group thickness; as applied to Table II, it means all the plates of each group width and group weight.

(d) **Plates, when Ordered to Weight per Square Foot.**—The weight of each lot[1] of plates in each shipment shall not vary from the weight ordered more than the amounts prescribed in Table II.

(e) **Plates over 2 in. in Thickness.**—Each plate over 2 in. in thickness shall conform to the permissible variations over ordered thickness prescribed in Table III.

TABLE III. PERMISSIBLE VARIATIONS OVER ORDERED THICKNESS OF PLATES OVER 2 IN. IN THICKNESS.

Specified Thickness, Inches	Variations over Specified Thickness for Widths Given					
	Under 36	36 to 60, excl.	60 to 84, excl.	84 to 120, excl.	120 to 132, excl.	132 and over
Over 2 to 3, excl.	1/16	3/32	7/64	1/8	1/8	9/64
3 to 4, "	5/64	3/32	7/64	1/8	1/8	9/64
4 to 6, "	3/32	1/8	9/64	9/64	5/32	11/64
6 to 8, "	7/64	1/8	5/32	5/32	11/64	
8 to 10, "		11/64	3/16	3/16		
10 to 12, "		3/16	15/64	15/64		
12 to 15, incl.		7/32	1/4			

Finish.

14. (a) The material shall be free from injurious defects and shall have a workmanlike finish.

(b) Surface imperfections that do not affect the full utility of the pieces shall not be considered as injurious defects in structural shapes 3/8 in. or more in thickness. Such pieces may be processed by the following methods in order to give them a workmanlike finish:

(1) When the surface imperfections are less than 1/16 in. in depth, they may be removed by grinding.

(2) When the surface imperfections are 1/16 in. or more in depth, the pieces may be subjected to chipping and welding under limiting conditions as follows:

The cross-sectional area of any piece shall not be reduced more than 1.5 per cent at any point, nor shall the total area of the chipped surface of any piece exceed 2 per cent of the total surface area of that piece.

After any imperfection has been completely removed, the maximum depth of depression shall not exceed the following:

Thickness of Material, in.	Depth of Depression, max., in.
3/8 up to 1/2	1/16
1/2 up to 1	1/8
1 up to 1 1/4	3/16
1 1/4 up to 2 1/4	1/4
2 1/4 up to 3 1/2	3/8

An experienced mill inspector shall inspect the work after the chipping operation to see that the defects have been completely removed and that the limitations specified above have not been exceeded. The inspector representing the purchaser shall be

given full opportunity to make this same inspection. All welding shall be done by qualified welders using suitable coated welding rods. The welds shall be sound; the weld metal being thoroughly fused on all surfaces and edges without undercutting or overlap. Weld metal shall project at least $\frac{1}{16}$ in. above the rolled surface after welding, and the projecting metal shall be removed by grinding or by chipping and grinding to make it flush with the rolled surface and produce a workmanlike finish.

Marking.

15. The name or brand of the manufacturer and the melt number shall be legibly stamped or rolled on all finished material, except that lattice bars and other small sections shall, when loaded for shipment, be properly separated and marked for identification. The identification marks shall be legibly stamped on the end of each pin and roller. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

Inspection.

16. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

17. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 8 shall be reported to the manufacturer within five working days from the receipt of samples by the purchaser.

(b) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.

18. Samples tested in accordance with Section 8 that represent rejected material shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

AMERICAN SOCIETY FOR TESTING MATERIALS

STANDARD SPECIFICATIONS FOR STRUCTURAL RIVET STEEL

A. S. T. M. DESIGNATION: A 141-39

Scope.

1. These specifications cover soft carbon steel for rivets for structural purposes.

Process.

2. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

Chemical Composition.

3. The steel shall conform to the following requirements as to chemical composition:

Phosphorus, max., per cent	Acid	0.06
	Basic	0.04
Sulfur, max., per cent		0.05
Copper, when copper steel is specified, min., per cent		0.20

Ladle Analysis.

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, and sulfur; also copper when copper steel is specified. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and the percentages of phosphorus and sulfur, and copper when copper steel is specified, shall conform to the requirements specified in Section 3.

Check Analysis.

5. An analysis may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 3 by more than 25 per cent.

Tensile Properties.

6. (**a**) The material shall conform to the following requirements as to tensile properties:

Tensile strength, psi	52 000 to 62 000
Yield point, min., psi	0.5 tens. str.
but in no case less than	28 000
Elongation in 8 in., min., per cent	$\frac{1\ 500\ 000}{\text{Tens. str.}}$

(**b**) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Bending Properties.

7. The bend test specimen shall stand being bent cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

Test Specimens.

8. **(a)** Test specimens shall be of the full diameter of the bars as rolled.

(b) Tension and bend test specimens for rivet bars which have been cold-drawn shall be normalized before testing.

Number of Tests.

9. **(a)** One tension test and one bend test shall be made from each melt; except that if bars from one melt differ 3/8 in. or more in diameter, one tension and one bend test shall be made from both the greatest and least diameters rolled.

(b) If any test specimen develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (a) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Permissible Variations in Diameter.

10. The diameter of rivet bars shall not vary from the size specified by more than the amounts prescribed in Table I.

TABLE I.—PERMISSIBLE VARIATIONS IN THE SIZE OF HOT-ROLLED ROUNDS AND SQUARES.

Specified Size, in.	Variations from Size, in.		Out-of-Round or Square, In.
	Over	Under	
5/16 and under	0.005	0.005	0.008
Over 5/16 to 7/16, incl.	0.006	0.006	0.009
Over 7/16 to 5/8, incl.	0.007	0.007	0.010
Over 5/8 to 7/8, incl.	0.008	0.008	0.012
Over 7/8 to 1, incl.	0.009	0.009	0.013
Over 1 to 1 1/8, incl.	0.010	0.010	0.015
Over 1 1/8 to 1 1/4, incl.	0.011	0.011	0.016
Over 1 1/4 to 1 3/8, incl.	0.012	0.012	0.018
Over 1 3/8 to 1 1/2, incl.	0.014	0.014	0.021
Over 1 1/2 to 2, incl.	1/64	1/64	0.023

NOTE.—Out-of-round is the difference between the maximum and minimum diameters of the bar, measured at the same cross-section. Out-of-square is the difference in the two dimensions at the same cross-section of a square bar.

Finish.

11. The bars shall be free from injurious defects and shall have a workmanlike finish.

Marking.

12. Rivet bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and the melt number for identification. The melt number shall be legibly marked on each test specimen.

Inspection.

13. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

14. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported to the manufacturer within five working days from the receipt of samples by the purchaser.

(b) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.

15. Samples tested in accordance with Section 5 that represent rejected material shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

A. I. S. C.

RECOMMENDED FUNDAMENTAL PRINCIPLES, MINIMUM REQUIREMENTS, AND TENTATIVE STANDARD

WELDED CONNECTIONS

FOR BUILDINGS

The use of the arc welding process plays an increasing part in the fabrication of structural steel buildings:

(**a**) as an aid to shop assembling processes ("tack welding"),

(**b**) as the final method of joining parts for transfer of stresses, in shop or field ("strength-welding").

The art of designing and detailing for the safe and economical employment of strength-welding is a relatively new and changing one; the economy of a welded structure as compared with a riveted or riveted-and-bolted one, is as yet a subject not for general statements but for estimate of the individual case.

In 1938 the Board of Directors of the American Institute of Steel Construction appointed a committee to formulate a statement of fundamental principles, minimum requirements, and recommendations for standard welded connections for tier buildings.

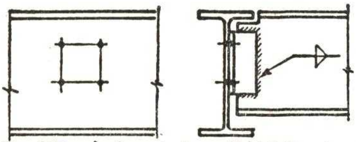
After careful study this committee concluded that the subject was not sufficiently stabilized to justify issuing complete standard details; but it evolved certain tentative minimum requirements and recommended tentative typical details which are shown on the three pages which follow.

The recommendations of this committee are largely reflected, together with those of the American Welding Society's Committee on Building Codes, in the several portions of the A.I.S.C. Specification (pp. 275 to 305) which apply to welded design and construction. It is therein prescribed that heavily coated electrodes, only, may be used. It is understood that all of the requirements of that specification are to be followed in the calculating, the detailing and the execution of welded structures.

The general question of rigidity or flexibility of connections is of primary importance in welded design, and is to be determined by the designer and not by the detailer. The designer should determine whether the connections are to be rigid or flexible and indicate this on the design drawings, preferably by sketches. Except as otherwise indicated by the designer, beam-to-column connections are to be designed as flexible; the beam connections recommended on page 338 are of a flexible type which will permit the beams to rotate sufficiently to accommodate their deflections under load.

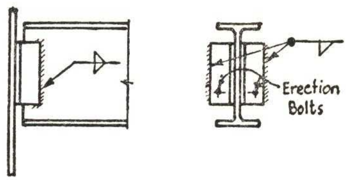
The typical details which follow are presented as a general guide to designers. It is hoped that a more expanded treatment, including sizes and capacities, can be presented at an early date.

RECOMMENDED TENTATIVE STANDARD DETAILS

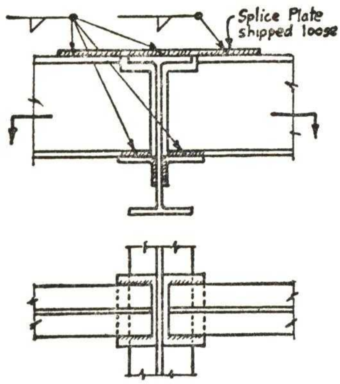


For Filling-In Beams where Field Bolting is permitted

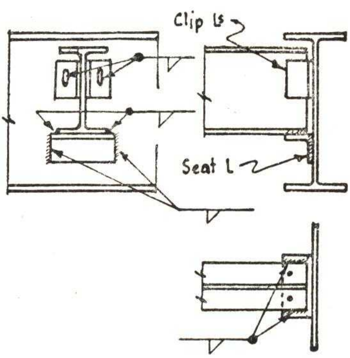
BEAM WELDED — HOLES IN GIRDER



FOR FILLING-IN BEAMS



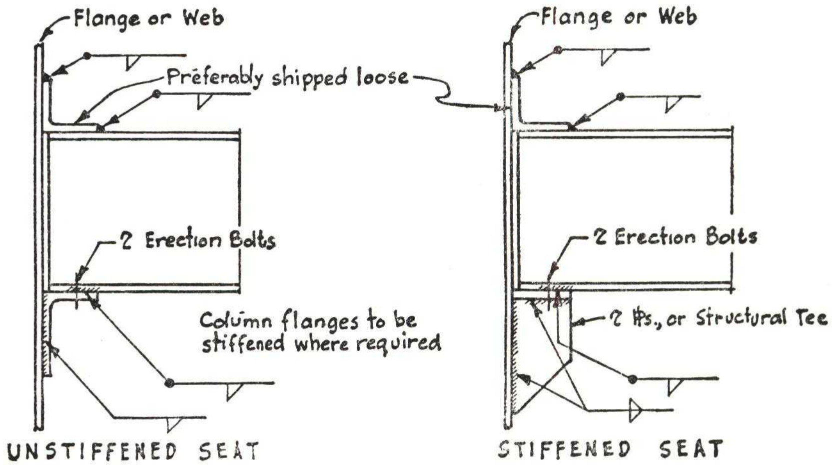
BEAM CONTINUOUS OVER GIRDER



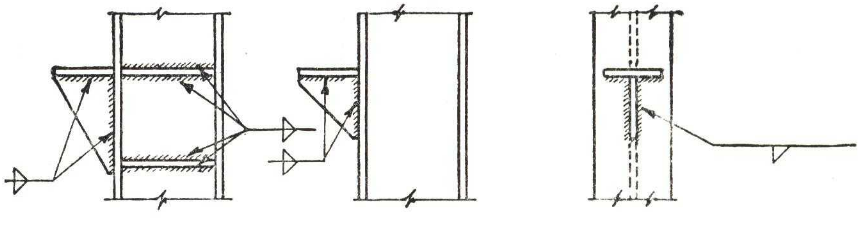
BEAM TO GIRDER

TYPICAL BEAM DETAILS

RECOMMENDED TENTATIVE STANDARD DETAILS

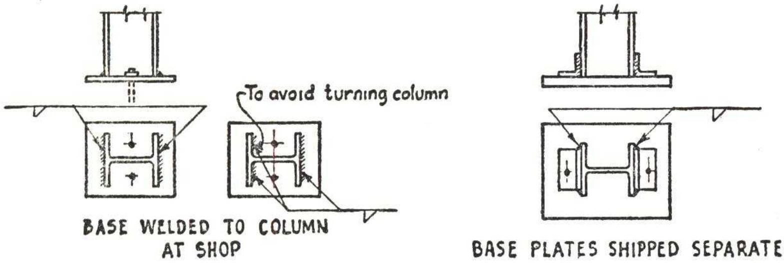


SIMPLE BEAM TO COLUMN CONNECTIONS

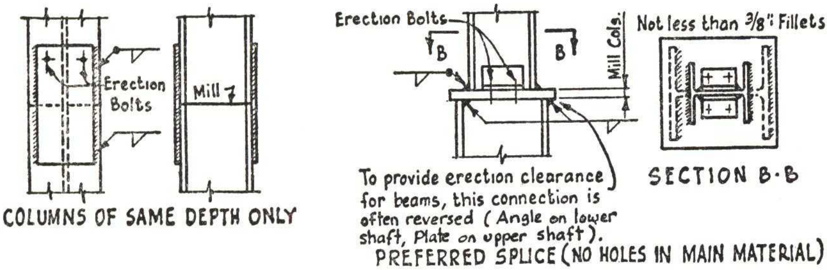


2-PLATE OR TEE BRACKETS CARRYING ECCENTRIC LOADS

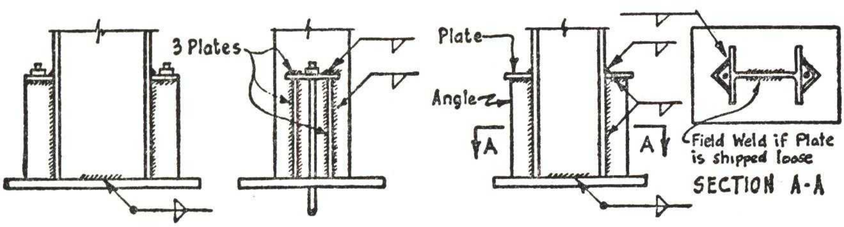
RECOMMENDED TENTATIVE STANDARD DETAILS



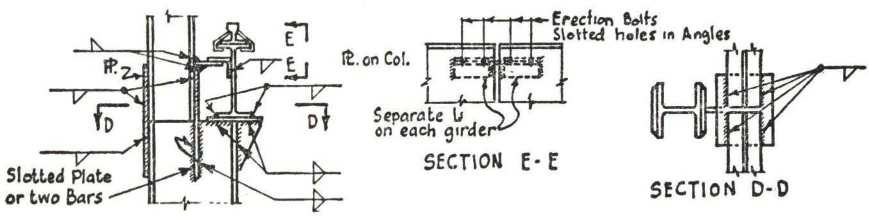
TYPICAL DETAILS OF COLUMN BASES—TIER BLDGS.



TYPICAL DETAILS OF COLUMN SPLICES—TIER BLDGS.

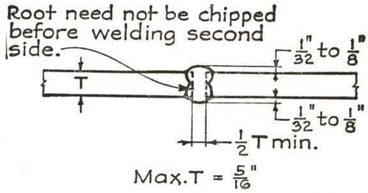


TYPICAL DETAILS OF CRANE COLUMN BASES

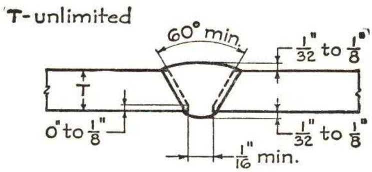


TYPICAL DETAILS OF CRANE COLUMN SPLICES

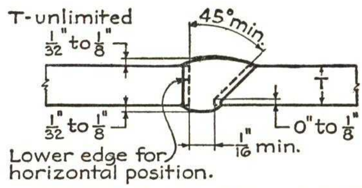
WELDED JOINTS



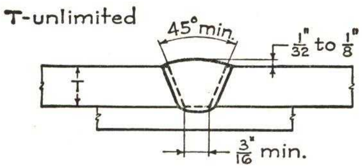
OPEN SQUARE-BUTT JOINT
WELDED BOTH SIDES



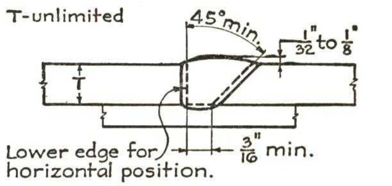
SINGLE-V BUTT JOINT
WELDED BOTH SIDES



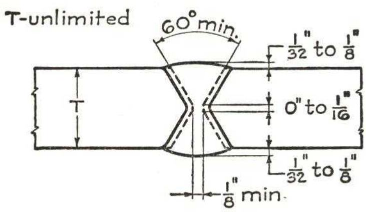
SINGLE BEVEL BUTT JOINT
WELDED BOTH SIDES



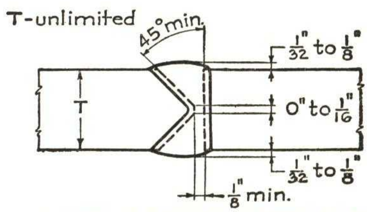
SINGLE-V BUTT JOINT, WELDED
ONE SIDE ON BACKING STRUCTURE



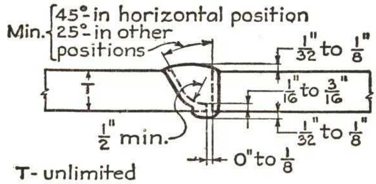
SINGLE BEVEL BUTT JOINT, WELDED
ONE SIDE ON BACKING STRUCTURE



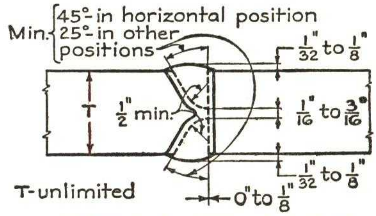
DOUBLE-V BUTT JOINT



DOUBLE BEVEL BUTT JOINT



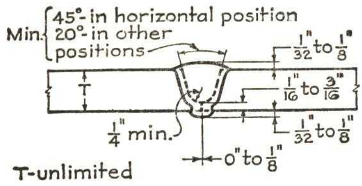
SINGLE-J BUTT JOINT
WELDED BOTH SIDES



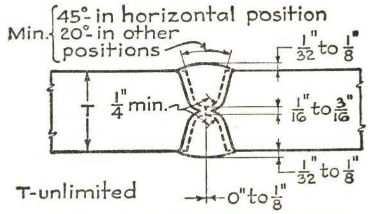
DOUBLE-J BUTT JOINT

The above joints are accepted without qualification under the A. W. S. Code and under A. I. S. C. Specification Sect. 24 (b).

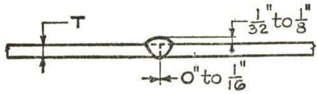
WELDED JOINTS



SINGLE-U BUTT JOINT
WELDED BOTH SIDES

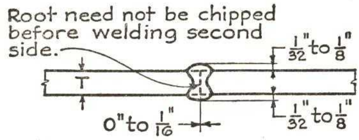


DOUBLE-U BUTT JOINT



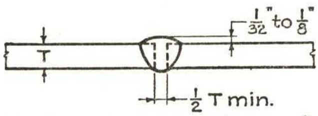
Effective Throat Thickness = $\frac{1}{2}$T
Max T = $\frac{1}{8}$"

SQUARE-BUTT JOINT
WELDED ONE SIDE



Effective Throat Thickness = $\frac{3}{4}$T
Max. T = $\frac{1}{4}$"

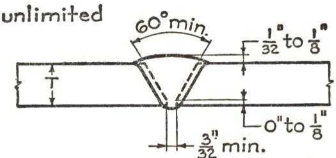
SQUARE-BUTT JOINT
WELDED BOTH SIDES



Effective Throat Thickness = $\frac{3}{4}$T
Max. T = $\frac{1}{4}$"

OPEN SQUARE-BUTT JOINT
WELDED ONE SIDE

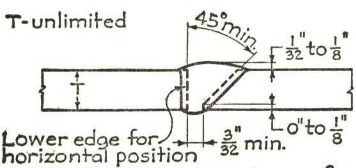
T-unlimited



Effective Throat Thickness = $\frac{3}{4}$T

SINGLE-V BUTT JOINT
WELDED ONE SIDE

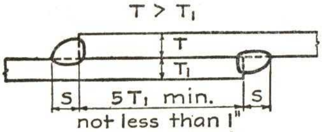
T-unlimited



Effective Throat Thickness = $\frac{3}{4}$T

SINGLE BEVEL BUTT JOINT
WELDED ONE SIDE

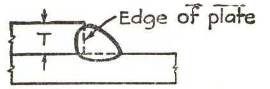
$T > T_1$



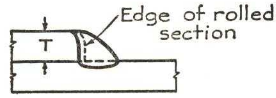
not less than 1"
S = as required

DOUBLE FILLET WELDED
LAP JOINT

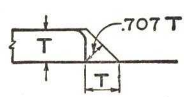
SEE A. I. S. C. SPEC. SECT. 25 (c)



Max. Effective Fillet = T - $\frac{1}{16}$"



Max. Effective Fillet = $\frac{3}{4}$ T



Max. Effective Fillet = T

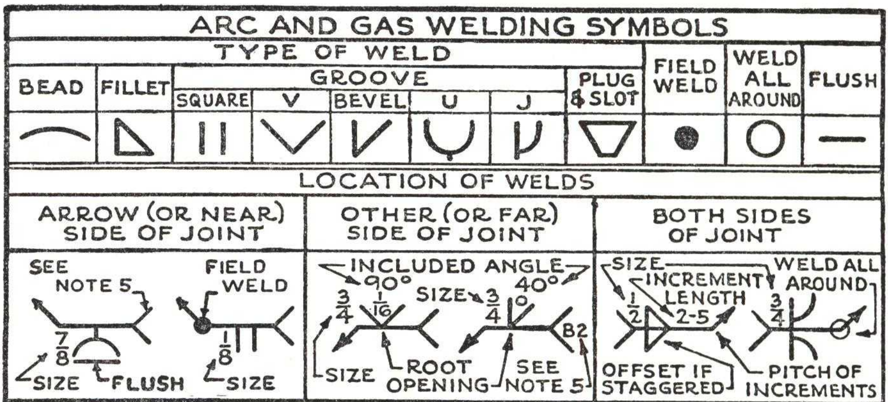
EDGE FILLET WELDS

SEE A. I. S. C. SPEC. SECT. 24 (d)

The above joints are accepted without qualification under the A. W. S. Code and under A. I. S. C. Specification Sect. 24 (b).

AMERICAN WELDING SOCIETY

WELDING SYMBOLS



1. THE SIDE OF THE JOINT TO WHICH THE ARROW POINTS IS THE ARROW (OR NEAR) SIDE AND THE OPPOSITE SIDE OF THE JOINT IS THE OTHER (OR FAR) SIDE.
2. ARROW SIDE AND OTHER SIDE WELDS ARE SAME SIZE UNLESS OTHERWISE SHOWN.
3. SYMBOLS APPLY BETWEEN ABRUPT CHANGES IN DIRECTION OF JOINT OR AS DIMENSIONED, (EXCEPT WHERE ALL AROUND SYMBOL IS USED).
4. ALL WELDS ARE CONTINUOUS AND OF USER'S STANDARD PROPORTIONS, UNLESS OTHERWISE SHOWN
5. TAIL OF ARROW USED FOR SPECIFICATION REFERENCE (TAIL MAY BE OMITTED WHEN REFERENCE NOT USED.)
   E. G. "C. A."—AUTOMATIC SHIELDED CARBON ARC
   "S. A."—AUTOMATIC SUBMERGED ARC
6. IN JOINTS IN WHICH ONE MEMBER ONLY IS TO BE GROOVED, ARROW POINTS TO THAT MEMBER
7. DIMENSIONS OF WELD SIZES, INCREMENT LENGTHS, AND SPACINGS, IN INCHES.

LEGEND FOR USE ON DRAWINGS SPECIFYING FUSION WELDING

The above symbols were developed by American Welding Society for incorporation on drawings specifying arc or gas welding. For more detailed instruction in the use of these symbols refer to "Welding Symbols and Instructions for Their Use", published by American Welding Society.

These symbols do not explicitly provide for the case that frequently occurs in structural work, where duplicate material (such as stiffeners) occurs on the far side of a web or gusset plate. The fabricating industry has adopted this convention; that when the billing of the detail material discloses the identity of far side with near side, the welding shown for the near side shall also be duplicated on the far side.

UNITED STATES DEPARTMENT OF COMMERCE

MINIMUM DESIGN LOADS IN BUILDINGS AND OTHER STRUCTURES

FROM AMERICAN STANDARD BUILDING CODE REQUIREMENTS A58.1—1945
NATIONAL BUREAU OF STANDARDS, SPONSOR.

UNIFORMLY DISTRIBUTED FLOOR LOADS

The live loads assumed for purposes of design shall be the greatest loads that probably will be produced by the intended occupancies or uses, provided that the live loads to be considered as uniformly distributed shall be not less than the values given in the following table.

Occupancy or Use	Live Load Lb. per Sq. Ft.	Occupancy or Use	Live Load Lb. per Sq. Ft.
Apartment houses:		Hotels:	
Private apartments	40	Guest rooms	40
Public stairways	100	Corridors serving public rooms	100
Assembly halls:		Public rooms	100
Fixed seats	60	Loft buildings	125
Movable seats	100	Manufacturing, light	125
Corridors, upper floors	100	Office buildings:	
Corridors:		Offices	80
First floor	100	Lobbies	100
Other floors, same as occupancy served except as indicated		Schools:	
Courtrooms	80	Classrooms	40
Dance halls	100	Corridors	100
Dining rooms, public	100	Stores	125
Dwellings	40	Theatres:	
Hospitals and asylums:		Aisles, corridors, and lobbies	100
Operating rooms	60	Orchestra floor	60
Private rooms	40	Balconies	60
Wards	40	Stage floor	150
Public space	80		

PROVISION FOR PARTITIONS

In office buildings or other buildings where partitions might be subject to erection or rearrangement, provision for partition weight shall be made, whether or not partitions are shown on the plans, unless the specified live load exceeds 80 pounds per square foot.

CONCENTRATED LOADS

In the design of floors, consideration shall be given to the effects of known or probable concentrations of load to which they may be subjected. Floors shall be designed to carry the specified distributed loads, or the following minimum concentrations, whichever may produce the greater stresses. The indicated concentrations shall be assumed to occupy areas 2½ feet square and to be so placed as to produce maximum stresses in the affected members.

Floor Space	Load
Office floors, including corridors	2,000 lb.
Garages	Maximum wheel load
Trucking space within building	Maximum wheel load

PARTIAL LOADING

When the construction is such that the structural elements thereof act together in the nature of an elastic frame due to their continuity and the rigidity of the connections, and the live load exceeds 150 pounds per square foot or twice the dead load, the effect of partial live load such as will produce maximum stress in any member shall be provided for in the design.

IMPACT LOADS

The live loads tabulated above may be assumed to include a sufficient allowance to cover the effects of ordinary impact. For special occupancies and loads involving unusual impacts, such as those resulting from moving machinery, elevators, craneways, vehicles, etc., provision shall be made by a suitable increase in the assumed live load.

REDUCTION OF LIVE LOAD

(a) No reduction shall be applied to the roof live load.

(b) For live loads of 100 pounds or less per square foot, the design live load on any member supporting 150 square feet or more may be reduced at the rate of 0.08 percent per square foot of area supported by the member, except that no reduction shall be made for areas to be occupied as places of public assembly. The reduction shall exceed neither R as determined by the following formula, nor 60 percent:

$$R = 100 \times \frac{D + L}{4.33L}$$

in which R = reduction in percent
D = dead load per square foot of area supported by the member
L = design live load per square foot of area supported by the member

For live loads exceeding 100 pounds per square foot, no reduction shall be made, except that the design live loads on columns may be reduced 20 percent.

ROOF LOADS (INCLUDING SNOW LOADS)

(a) Ordinary roofs, either flat or pitched, shall be designed for a load of not less than 20 pounds per square foot of horizontal projection in addition to the dead load, and in addition to either the wind or the earthquake load, whichever produces the greater stresses.

(NOTE: The figure of 20 pounds per square foot is a minimum snow load and should be increased in many localities. A U. S. Weather Bureau map in the Appendix to A58.1–1945 indicates roughly that such an increase is in order north of the 40th parallel of latitude; attaining 40 pounds per square foot at the northeastern and north central boundaries of the United States and in parts of Washington, Oregon and Idaho.)

(b) Roofs to be used for promenades shall be designed for a minimum load of 60 pounds per square foot in addition to the dead load. Roofs to be used for other special purposes shall be designed for appropriate loads as directed or approved by the building official.

OTHER LIVE LOADS

(a) Stair treads shall be designed to support a uniformly distributed load of 100 pounds per square foot, or concentrated loads of 300 pounds spaced 3 feet center to center, each occupying an area 1 foot wide by the depth of the tread, whichever will produce the greater stresses.

(b) Sidewalks shall be designed to support either a uniformly distributed load of 250 pounds per square foot, or a concentrated load of 8,000 pounds on an area 2½ feet square placed in any position, whichever will produce the greater stresses.

(c) Driveways shall be designed to support a uniformly distributed load of 100 pounds per square foot for vehicles weighing less than 3 tons with load, 150 pounds per square foot for vehicles weighing 3 to 10 tons with load, 200 pounds per square foot for vehicles weighing over 10 tons with load, or a concentrated load equal to the maximum expected wheel load on an area 2½ feet square placed in any position, whichever will produce the greater stresses.

(d) Accessible ceilings, scuttles, and ribs of skylights shall be designed to support a concentrated load of 200 pounds occupying an area 2½ feet square and so placed as to produce maximum stresses in the affected members.

(e) Stairway and balcony railings, both exterior and interior, shall be designed to resist a horizontal thrust of 50 pounds per linear foot applied at the top of the railing.

PART V

MISCELLANEOUS DATA AND MATHEMATICAL TABLES

STRENGTH OF MATERIALS

METALS AND ALLOYS

Material	Stress in Kips per Square Inch					Modulus of Elasticity Pounds per Sq. In.	Elongation Per cent
	Tension Ultimate	Elastic Limit	Compression Ultimate	Bending Ultimate	Shearing Ultimate		
Aluminum, Alloy 2014	62-70	42-60			38-42	10,600,000	†20-13
" " 6061	35-41	21-40			24-30	10,000,000	†22-12
Brass, 50% Zn	31	17.9	117	33.5			5.0
" cast, common	18-24	6	30	20	36	9,000,000	
" wire, hard	80						
" " annealed	50	16				14,000,000	
Bronze, aluminum 5 to 7½%	75	40	120				
" Tobin, cast (38% Zn, 1½% Sn, ⅓% Pb)	66						
" " rolled (38% Zn, 1½% Sn, ⅓% Pb)	80	40				14,500,000	
" " c. " (38% Zn, 1½% Sn, ⅓% Pb)	100						
Copper, plates, rods, bolts	32-35	10	32				
Iron, cast, gray	18-24			25-33			
" " malleable	27-35	15-20	46	30	40		
" wrought, shapes	48	26	Tensile	Tensile	⅚ Tens.	28,000,000	
Steel, plates for cold pressing	48-58	½ Tens.	Tensile	Tensile	¾ Tens.	29,000,000	*1,500,000 / Tensile Strength
" cars	50-65	½ Tens.	Tensile	Tensile	¾ Tens.	29,000,000	
" locos., stat. boilers	55-65	½ Tens.	Tensile	Tensile	¾ Tens.	29,000,000	
" bridges and bldgs., ships	60-72	33	Tensile	Tensile	¾ Tens.	29,000,000	
" structural silicon	80-95	45	Tensile	Tensile	¾ Tens.	29,000,000	
" struc. nickel (3.25% Ni)	85-100	50	Tensile	Tensile	¾ Tens.	29,000,000	
Steel, rivet, boiler	45-55	½ Tens.	Tensile	Tensile	¾ Tens.	29,000,000	
" " br.,bldg.,loco., cars	52-62	28	Tensile	Tensile	¾ Tens.	29,000,000	
" " ships	55-65	30	Tensile	Tensile	¾ Tens.	29,000,000	
" " high-tensile	70-85	38	Tensile	Tensile	¾ Tens.	29,000,000	
Steel, cast, soft	60	27	Tensile	Tensile	¾ Tens.	29,000,000	†24
" " medium	70	31.5	Tensile	Tensile	¾ Tens.	29,000,000	†20
" " hard	80	36	Tensile	Tensile	¾ Tens.	29,000,000	†17
Steel wire, unannealed	120	60					
" " annealed	80	40					
" " bridge cable	215	95					

* 8″ gage length
† 2″ gage length

BUILDING MATERIALS

Material	Average Ultimate Stress Pounds per Square Inch			Safe Working Stress Pounds per Square Inch			Modulus of Elasticity Pounds per Sq. In.
	Compression	Tension	Bending	Compression	Bearing	Shearing	
Masonry, granite				420	600		
" limestone, bluestone				350	500		
" sandstone				280	400		
" rubble				140	250		
" brick, common	10000	200	600				
Ropes, cast steel hoisting		80000					
" standing, derrick		70000					
" manila		8000					
Stone, bluestone	12000	1200	2500	1200	1200	200	7,000,000
" granite, gneiss	12000	1200	1600	1200	1200	200	7,000,000
" limestone, marble	8000	800	1500	800	800	150	7,000,000
" sandstone	5000	150	1200	500	500	150	3,000,000
" slate	10000	3000	5000	1000	1000	175	14,000,000

EFFECT OF HEAT ON STRUCTURAL STEEL

The Institute has published in previous editions of the Manual, an "A.I.S.C. Specification for Fireproofing Structural Steel for Buildings". Since the method of fire testing recommended in that Specification is now incorporated in Specification A.S.T.M. C-19-46, under the heading "Alternative Tests for Steel Columns", this Manual no longer contains the full text of the A.I.S.C. Specification.

Certain pertinent data, substantially as it has hitherto appeared in the Specification, is given below. This data refers only to ordinary structural carbon steel, such as A.S.T.M.-A-7 (Page 326).

The occasion for fireproofing structural steel is to insulate it against a rise of temperature that would seriously impair its ability to sustain the loads at the unit stresses used in the design.

The strength of structural steel at approximately 550° F. is about 25 percent greater than its strength at normal temperature, and at 800° F. its strength is approximately the same as at normal temperature. Steel buildings whose condition of exterior exposure and whose contents under fire hazards will not produce a temperature greater than 800° F. in the steel, may therefore be considered fire-resistive without the provision of insulating protection for the steel.

At a temperature of 1000° F. the ultimate compression strength of structural steel may be (depending upon the proportions of the member) lowered almost to the maximum permissible working stress specified by A.I.S.C. for columns. Therefore, where a fire exposure of severity and duration sufficient to raise the temperature to this figure becomes a possibility by reason of the presence of the necessary combustibles, the steel members upon which the stability of the structure depends, should be insulated by materials and constructions capable of holding the temperature of the steel to not more than 1000° F. for the probable duration of the exposure.

The average coefficient of expansion for structural steel between the temperatures of 200° F. and 1100° F. is given by the formula

$$C = .0000061 + .0000000022\ t$$

in which C is the coefficient of expansion for each degree Fahrenheit, and t is the temperature in degrees Fahrenheit. From 1100° F. to 1400° F. there is a slight variation in the coefficient, and below 200° F. the variation is less than that at the higher temperatures.

The modulus of elasticity of steel decreases as the temperature increases. The modulus for temperatures between 200° F. and 1300° F. is given approximately by the formula

$$E = 32{,}400{,}000 - 17{,}000\ t$$

in which E is the initial modulus of elasticity in pounds per square inch and t is the temperature in degrees Fahr. Between room temperature and 200° F. there is a smaller variation in E.

EXPANSION OF BODIES BY HEAT

The coefficient of linear expansion (ϵ) is the change in length, per unit of length, for a change of one degree of temperature. The coefficient of surface expansion is approximately two times the linear coefficient, and the coefficient of volume expansion, for solids, is approximately three times the linear coefficient.

A bar, free to move, will increase in length with an increase in temperature and will decrease in length with a decrease in temperature. The change in length will be ϵtl, where ϵ is the coefficient of linear expansion, t the change in temperature, and l the length. If the ends of a bar are fixed, a change in temperature (t) will cause a change in the unit stress of $E\epsilon t$, and in the total stress of $AE\epsilon t$, where A is the cross sectional area of the bar and E the modulus of elasticity.

The following table gives the coefficient of linear expansion for 100°, or 100 times the value indicated above.

Example: A piece of medium steel is exactly 40 feet long at 60° F. Find the length at 90° F. assuming the ends free to move.

$$\text{Change of length} = \epsilon tl = \frac{.00067 \times 30 \times 40}{100} = .00804 \text{ foot.}$$

The length at 90° F. is 40.00804 feet.

Example: A piece of medium steel is exactly 40 feet long and the ends are fixed. If the temperature increases 30° F., what is the resulting change in the unit stress?

$$\text{Change in unit stress} = E\epsilon t = \frac{29{,}000{,}000 \times .00067 \times 30}{100} = 5830 \text{ lbs. per sq. in.}$$

COEFFICIENTS OF EXPANSION FOR 100 DEGREES = 100ϵ

Materials	Linear Expansion Centigrade	Linear Expansion Fahrenheit	Materials	Linear Expansion Centigrade	Linear Expansion Fahrenheit
METALS AND ALLOYS			**STONE AND MASONRY**		
Aluminum, wrought	.00231	.00128	Ashlar masonry	.00063	.00035
Brass	.00188	.00104	Brick masonry	.00061	.00034
Bronze	.00181	.00101	Cement, portland	.00126	.00070
Copper	.00168	.00093	Concrete	.00099	.00055
Iron, cast, gray	.00106	.00059	Granite	.00080	.00044
Iron, wrought	.00120	.00067	Limestone	.00076	.00042
Iron, wire	.00124	.00069	Marble	.00081	.00045
Lead	.00286	.00159	Plaster	.00166	.00092
Magnesium, various alloys	.0029	.0016	Rubble masonry	.00063	.00035
Nickel	.00126	.00070	Sandstone	.00097	.00054
Steel, cast	.00110	.00061	Slate	.00080	.00044
Steel, hard	.00132	.00073			
Steel, medium	.00120	.00067			
Steel, soft	.00110	.00061			
Steel, stainless, 18-8	.00178	.00099			
Zinc, rolled	.00311	.00173			
TIMBER			**TIMBER**		
Fir, parallel to fiber	.00037	.00021	Fir, perpendicular to fiber	.0058	.0032
Maple, parallel to fiber	.00064	.00036	Maple, perpendicular to fiber	.0048	.0027
Oak, parallel to fiber	.00049	.00027	Oak, perpendicular to fiber	.0054	.0030
Pine, parallel to fiber	.00054	.00030	Pine, perpendicular to fiber	.0034	.0019

EXPANSION OF WATER

MAXIMUM DENSITY = 1

C°	Volume	C°	Volume	C°	Volume	C°	Volume	C°	Volume	C°	Volume
0	1.000126	10	1.000257	30	1.004234	50	1.011877	70	1.022384	90	1.035829
4	1.000000	20	1.001732	40	1.007627	60	1.016954	80	1.029003	100	1.043116

WEIGHTS AND SPECIFIC GRAVITIES

Substance	Weight Lb. per Cu. Ft.	Specific Gravity
METALS, ALLOYS, ORES		
Aluminum, cast, hammered	165	2.55-2.75
Brass, cast, rolled	534	8.4-8.7
Bronze, 7.9 to 14% Sn	509	7.4-8.9
Bronze, aluminum	481	7.7
Copper, cast, rolled	556	8.8-9.0
Copper ore, pyrites	262	4.1-4.3
Gold, cast, hammered	1205	19.25-19.3
Iron, cast, pig	450	7.2
Iron, wrought	485	7.6-7.9
Iron, spiegel-eisen	468	7.5
Iron, ferro-silicon	437	6.7-7.3
Iron ore, hematite	325	5.2
Iron ore, hematite in bank	160-180	-------
Iron ore, hematite loose	130-160	-------
Iron ore, limonite	237	3.6-4.0
Iron ore, magnetite	315	4.9-5.2
Iron slag	172	2.5-3.0
Lead	710	11.37
Lead ore, galena	465	7.3-7.6
Magnesium, alloys	112	1.74-1.83
Manganese	475	7.2-8.0
Manganese ore, pyrolusite	259	3.7-4.6
Mercury	849	13.6
Monel Metal	556	8.8-9.0
Nickel	565	8.9-9.2
Platinum, cast, hammered	1330	21.1-21.5
Silver, cast, hammered	656	10.4-10.6
Steel, rolled	490	7.85
Tin, cast, hammered	459	7.2-7.5
Tin ore, cassiterite	418	6.4-7.0
Zinc, cast, rolled	440	6.9-7.2
Zinc ore, blende	253	3.9-4.2

Substance	Weight Lb. per Cu. Ft.	Specific Gravity
VARIOUS SOLIDS		
Cereals, oats ..... bulk	32	-------
Cereals, barley ..... bulk	39	-------
Cereals, corn, rye ..... bulk	48	-------
Cereals, wheat ..... bulk	48	-------
Hay and Straw ..... bales	20	-------
Cotton, Flax, Hemp	93	1.47-1.50
Fats	58	0.90-0.97
Flour, loose	28	0.40-0.50
Flour, pressed	47	0.70-0.80
Glass, common	156	2.40-2.60
Glass, plate or crown	161	2.45-2.72
Glass, crystal	184	2.90-3.00
Leather	59	0.86-1.02
Paper	58	0.70-1.15
Potatoes, piled	42	-------
Rubber, caoutchouc	59	0.92-0.96
Rubber goods	94	1.0-2.0
Salt, granulated, piled	48	-------
Saltpeter	67	-------
Starch	96	1.53
Sulphur	125	1.93-2.07
Wool	82	1.32

Substance	Weight Lb. per Cu. Ft.	Specific Gravity
TIMBER, U. S. SEASONED		
Moisture Content by Weight:		
Seasoned timber 15 to 20%		
Green timber up to 50%		
Ash, white, red	40	0.62-0.65
Cedar, white, red	22	0.32-0.38
Chestnut	41	0.66
Cypress	30	0.48
Fir, Douglas spruce	32	0.51
Fir, eastern	25	0.40
Elm, white	45	0.72
Hemlock	29	0.42-0.52
Hickory	49	0.74-0.84
Locust	46	0.73
Maple, hard	43	0.68
Maple, white	33	0.53
Oak, chestnut	54	0.86
Oak, live	59	0.95
Oak, red, black	41	0.65
Oak, white	46	0.74
Pine, Oregon	32	0.51
Pine, red	30	0.48
Pine, white	26	0.41
Pine, yellow, long-leaf	44	0.70
Pine, yellow, short-leaf	38	0.61
Poplar	30	0.48
Redwood, California	26	0.42
Spruce, white, black	27	0.40-0.46
Walnut, black	38	0.61
VARIOUS LIQUIDS		
Alcohol, 100%	49	0.79
Acids, muriatic 40%	75	1.20
Acids, nitric 91%	94	1.50
Acids, sulphuric 87%	112	1.80
Lye, soda 66%	106	1.70
Oils, vegetable	58	0.91-0.94
Oils, mineral, lubricants	57	0.90-0.93
Water, 4°C. max. density	62.428	1.0
Water, 100°C.	59.830	0.9584
Water, ice	56	0.88-0.92
Water, snow, fresh fallen	8	.125
Water, sea water	64	1.02-1.03
GASES		
Air, 0°C. 760 mm.	.08071	1.0
Ammonia	.0478	0.5920
Carbon dioxide	.1234	1.5291
Carbon monoxide	.0781	0.9673
Gas, illuminating	.028-.036	0.35-0.45
Gas, natural	.038-.039	0.47-0.48
Hydrogen	.00559	0.0693
Nitrogen	.0784	0.9714
Oxygen	.0892	1.1056

The specific gravities of solids and liquids refer to water at 4°C., those of gases to air at 0°C. and 760 mm. pressure. The weights per cubic foot are derived from average specific gravities, except where stated that weights are for bulk, heaped or loose material, etc.

WEIGHTS AND SPECIFIC GRAVITIES

Substance	Weight Lb. per Cu. Ft.	Specific Gravity
ASHLAR MASONRY		
Granite, syenite, gneiss	165	2.3-3.0
Limestone, marble	160	2.3-2.8
Sandstone, bluestone	140	2.1-2.4
MORTAR RUBBLE MASONRY		
Granite, syenite, gneiss	155	2.2-2.8
Limestone, marble	150	2.2-2.6
Sandstone, bluestone	130	2.0-2.2
DRY RUBBLE MASONRY		
Granite, syenite, gneiss	130	1.9-2.3
Limestone, marble	125	1.9-2.1
Sandstone, bluestone	110	1.8-1.9
BRICK MASONRY		
Pressed brick	140	2.2-2.3
Common brick	120	1.8-2.0
Soft brick	100	1.5-1.7
CONCRETE MASONRY		
Cement, stone, sand	144	2.2-2.4
Cement, slag, etc.	130	1.9-2.3
Cement, cinder, etc.	100	1.5-1.7
VARIOUS BUILDING MATERIALS		
Ashes, cinders	40-45	-------
Cement, portland, loose	90	-------
Cement, portland, set	183	2.7-3.2
Lime, gypsum, loose	53-64	-------
Mortar, set	103	1.4-1.9
Slags, bank slag	67-72	-------
Slags, bank screenings	98-117	-------
Slags, machine slag	96	-------
Slags, slag sand	49-55	-------
EARTH, ETC., EXCAVATED		
Clay, dry	63	-------
Clay, damp, plastic	110	-------
Clay and gravel, dry	100	-------
Earth, dry, loose	76	-------
Earth, dry, packed	95	-------
Earth, moist, loose	78	-------
Earth, moist, packed	96	-------
Earth, mud, flowing	108	-------
Earth, mud, packed	115	-------
Riprap, limestone	80-85	-------
Riprap, sandstone	90	-------
Riprap, shale	105	-------
Sand, gravel, dry, loose	90-105	-------
Sand, gravel, dry, packed	100-120	-------
Sand, gravel, dry, wet	118-120	-------
EXCAVATIONS IN WATER		
Sand or gravel	60	-------
Sand or gravel and clay	65	-------
Clay	80	-------
River mud	90	-------
Soil	70	-------
Stone riprap	65	-------

Substance	Weight Lb. per Cu. Ft.	Specific Gravity
MINERALS		
Asbestos	153	2.1-2.8
Barytes	281	4.50
Basalt	184	2.7-3.2
Bauxite	159	2.55
Borax	109	1.7-1.8
Chalk	137	1.8-2.6
Clay, marl	137	1.8-2.6
Dolomite	181	2.9
Feldspar, orthoclase	159	2.5-2.6
Gneiss, serpentine	159	2.4-2.7
Granite, syenite	175	2.5-3.1
Greenstone, trap	187	2.8-3.2
Gypsum, alabaster	159	2.3-2.8
Hornblende	187	3.0
Limestone, marble	165	2.5-2.8
Magnesite	187	3.0
Phosphate rock, apatite	200	3.2
Porphyry	172	2.6-2.9
Pumice, natural	40	0.37-0.90
Quartz, flint	165	2.5-2.8
Sandstone, bluestone	147	2.2-2.5
Shale, slate	175	2.7-2.9
Soapstone, talc	169	2.6-2.8
STONE, QUARRIED, PILED		
Basalt, granite, gneiss	96	-------
Limestone, marble, quartz	95	-------
Sandstone	82	-------
Shale	92	-------
Greenstone, hornblende	107	-------
BITUMINOUS SUBSTANCES		
Asphaltum	81	1.1-1.5
Coal, anthracite	97	1.4-1.7
Coal, bituminous	84	1.2-1.5
Coal, lignite	78	1.1-1.4
Coal, peat, turf, dry	47	0.65-0.85
Coal, charcoal, pine	23	0.28-0.44
Coal, charcoal, oak	33	0.47-0.57
Coal, coke	75	1.0-1.4
Graphite	131	1.9-2.3
Paraffine	56	0.87-0.91
Petroleum	54	0.87
Petroleum, refined	50	0.79-0.82
Petroleum, benzine	46	0.73-0.75
Petroleum, gasoline	42	0.66-0.69
Pitch	69	1.07-1.15
Tar, bituminous	75	1.20
COAL AND COKE, PILED		
Coal, anthracite	47-58	-------
Coal, bituminous, lignite	40-54	-------
Coal, peat, turf	20-26	-------
Coal, charcoal	10-14	-------
Coal, coke	23-32	-------

The specific gravities of solids and liquids refer to water at 4°C., those of gases to air at 0°C. and 760 mm. pressure. The weights per cubic foot are derived from average specific gravities, except where stated that weights are for bulk, heaped or loose material, etc.

WEIGHTS OF BUILDING MATERIALS

Materials	Weight Lb. per Sq. Ft.
CEILINGS	
Gypsum ceiling block, 2″ thick, unplastered	10
Plaster board, unplastered	3
Plaster, ¾″, and wood lath	8
Plaster, ¾″, and metal lath	8
Plaster, on tile or concrete	5
Suspended, metal lath and plaster	10
FLOORS	
Hardwood flooring, ⅞″ thick	4
Sheathing, white, red and Oregon pine, spruce or hemlock, ⅞″ thick	2½
Sheathing, yellow pine, 1″ thick	4
Wood block, creosoted, 3″ thick	15
Cement finish, per inch thick	12
Cinder concrete, per inch thick	9
Cinder concrete fill, per inch thick	5
Terrazzo, Tile, Mastic, Linoleum, per inch thick, including base	12
Gypsum slab, per inch thick	5
ROOFS	
Corrugated metal	Page 143
Roofing felt, 3 ply and gravel	5½
Roofing felt, 5 ply and gravel	6½
Roofing felt, 3 ply and slag	4½
Roofing felt, 5 ply and slag	5½
3-ply ready roofing	1
Shingles, wood	2
Tile or slate	5-20

Materials	Weight Lb. per Sq. Ft.
PARTITIONS	
Channel studs, metal lath, cement plaster, solid, 2″ thick	20
Studs, 2″ x 4″, wood or metal lath, ¾″ plaster both sides	18
Studs, 2″ x 4″ plaster board, ½″ plaster both sides	18
Plaster, ½″, on gypsum block or clay tile (one side)	4
Hollow clay tile, 2″	13
Hollow clay tile, 3″	16
Hollow clay tile, 4″	18
Hollow clay tile, 5″	20
Hollow clay tile, 6″	25
Hollow clay tile, 8″	30
Hollow clay tile, 10″	35
Hollow gypsum block, 3″	10
Hollow gypsum block, 4″	13
Hollow gypsum block, 5″	15½
Hollow gypsum block, 6″	16½
Solid gypsum block, 2″	9½
Solid gypsum block, 3″	13
Steel partitions	4
WALLS	
Brick, 9″ thick	84
Brick, 13″ thick	121
Brick, 18″ thick	168
Brick, 22″ thick	205
Brick, 26″ thick	243
Wall tile, 6″ thick	30
Wall tile, 8″ thick	33
Wall tile, 10″ thick	40
Wall tile, 12″ thick	45
Brick 4″, tile backing 4″	60
Brick 4″, tile backing 8″	75
Brick 9″, tile backing 4″	100
Brick 9″, tile backing 8″	115
Limestone 4″, brick 9″	140
Limestone 4″, brick 13″	175
Limestone 4″, tile 8″	90
Limestone 4″, tile 12″	100
Corrugated metal siding	Page 143
Windows, glass, frame and sash	8

For weights of other materials used in building construction, see pages 349 and 350.

RECOMMENDED LIVE LOADS
FOR
STORAGE WAREHOUSES

United States Department of Commerce, National Bureau of Standards

Material	Weight per Cubic Foot of Space Lb.	Height of Pile Feet	Weight per Square Foot of Floor Lb.	Recommended Live Load Lb. per Sq. Foot
BUILDING MATERIALS				
Asbestos	50	6	300	
Bricks, Building	45	6	270	
Bricks, Fire Clay	75	6	450	
Cement, Natural	59	6	354	300
Cement, Portland	72 to 105	6	432 to 630	to
Gypsum	50	6	300	400
Lime and Plaster	53	5	265	
Tiles	50	6	300	
Woods, bulk	45	6	270	
DRUGS, PAINTS, OIL, ETC.				
Alum, Pearl, in barrels	33	6	198	
Bleaching Powder, in hogsheads	31	3½	102	
Blue Vitriol, in barrels	45	5	226	
Glycerine, in cases	52	6	312	
Linseed Oil, in barrels	36	6	216	
Linseed Oil, in iron drums	45	4	180	
Logwood Extract, in boxes	70	5	350	
Rosin, in barrels	48	6	288	
Shellac, Gum	38	6	228	200
Soaps	50	6	300	to
Soda Ash, in hogsheads	62	2¾	167	300
Soda, Caustic, in iron drums	88	3⅜	294	
Soda, Silicate, in barrels	53	6	318	
Sulphuric Acid	60	1⅝	100	
Toilet Articles	35	6	210	
Varnishes	55	6	330	
White Lead Paste, in cans	174	3½	610	
White Lead, dry	86	4¾	408	
Red Lead and Litharge, dry	132	3¾	495	
DRY GOODS, COTTON, WOOL, ETC.				
Burlap, in bales	43	6	258	
Carpets and Rugs	30	6	180	
Coir Yarn, in bales	33	8	264	
Cotton, in bales, American	30	8	240	
Cotton, in bales, Foreign	40	8	320	
Cotton Bleached Goods, in cases	28	8	224	
Cotton Flannel, in cases	12	8	96	
Cotton Sheeting, in cases	23	8	184	
Cotton Yarn, in cases	25	8	200	
Excelsior, compressed	19	8	152	200
Hemp, Italian, compressed	22	8	176	to
Hemp, Manila, compressed	30	8	240	250
Jute, compressed	41	8	328	
Linen Damask, in cases	50	5	250	
Linen Goods, in cases	30	8	240	
Linen Towels, in cases	40	6	240	
Silk and Silk Goods	45	8	360	
Sisal, compressed	21	8	168	
Tow, compressed	29	8	232	
Wool, in bales, compressed	48			
Wool, in bales, not compressed	13	8	104	
Wool, Worsteds, in cases	27	8	216	

RECOMMENDED LIVE LOADS FOR STORAGE WAREHOUSES

United States Department of Commerce, National Bureau of Standards

Material	Weight per Cubic Foot of Space Lb.	Height of Pile Feet	Weight per Square Foot of Floor Lb.	Recommended Live Load Lb. per Sq. Ft.
GROCERIES, WINES, LIQUORS, ETC.				
Beans, in bags	40	8	320	
Beverages	40	8	320	
Canned Goods, in cases	58	6	348	
Cereals	45	8	360	
Cocoa	35	8	280	
Coffee, Roasted, in bags	33	8	264	
Coffee, Green, in bags	39	8	312	
Dates, in cases	55	6	330	
Figs, in cases	74	5	370	
Flour, in barrels	40	5	200	
Fruits, Fresh	35	8	280	250 to 300
Meat and Meat Products	45	6	270	
Milk, Condensed	50	6	300	
Molasses, in barrels	48	5	240	
Rice, in bags	58	6	348	
Sal Soda, in barrels	46	5	230	
Salt, in bags	70	5	350	
Soap Powder, in cases	38	8	304	
Starch, in barrels	25	6	150	
Sugar, in barrels	43	5	215	
Sugar, in cases	51	6	306	
Tea, in chests	25	8	200	
Wines and Liquors, in barrels	38	6	228	
HARDWARE, ETC.				
Automobile Parts	40	8	320	
Chain	100	6	600	
Cutlery	45	8	360	
Door Checks	45	6	270	
Electrical Goods and Machinery	40	8	320	
Hinges	64	6	384	
Locks, in cases, packed	31	6	186	
Machinery, Light	20	8	160	
Plumbing, Fixtures	30	8	240	
Plumbing, Supplies	55	6	330	300 to 400
Sash Fasteners	48	6	288	
Screws	101	6	606	
Shafting Steel	125			
Sheet Tin, in boxes	278	2	556	
Tools, Small, Metal	75	6	450	
Wire Cables, on reels			425	
Wire, Insulated Copper, in coils	63	5	315	
Wire, Galvanized Iron, in coils	74	4½	333	
Wire, Magnet, on spools	75	6	450	
MISCELLANEOUS				
Automobile Tires	30	6	180	
Automobiles, uncrated	8		64	
Books (solidly packed)	65	6	390	
Furniture	20			
Glass and Chinaware, in crates	40	8	320	
Hides and Leather, in bales	20	8	160	
Hides, Buffalo, in bundles	37	8	296	
Leather and Leather Goods	40	8	320	
Paper, Newspaper, and Strawboards	35	6	210	
Paper, Writing and Calendared	60	6	360	
Rope, in coils	32	6	192	
Rubber, Crude	50	8	400	
Tobacco, bales	35	8	280	

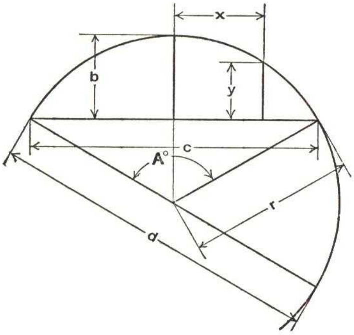
TIMBER
AMERICAN STANDARD SIZES
PROPERTIES FOR DESIGNING
NATIONAL LUMBER MANUFACTURERS ASSOCIATION

Nominal Size	American Standard Dressed Size	Area of Section	Weight per Foot	Moment of Inertia	Section Modulus
In.	In.	In.²	Lb.	In.⁴	In.³
2 x 4	1⅝x3⅝	5.89	1.64	6.45	3.56
6	5⅝	9.14	2.54	24.1	8.57
8	7½	12.2	3.39	57.1	15.3
10	9½	15.4	4.29	116	24.4
12	11½	18.7	5.19	206	35.8
14	13½	21.9	6.09	333	49.4
16	15½	25.2	6.99	504	65.1
18	17½	28.4	7.90	726	82.9
3 x 4	2⅝x3⅝	9.52	2.64	10.4	5.75
6	5⅝	14.8	4.10	38.9	13.8
8	7½	19.7	5.47	92.3	24.6
10	9½	24.9	6.93	188	39.5
12	11½	30.2	8.39	333	57.9
14	13½	35.4	9.84	538	79.7
16	15½	40.7	11.3	815	105
18	17½	45.9	12.8	1172	134
4 x 4	3⅝x3⅝	13.1	3.65	14.4	7.94
6	5⅝	20.4	5.66	53.8	19.1
8	7½	27.2	7.55	127	34.0
10	9½	34.4	9.57	259	54.5
12	11½	41.7	11.6	459	79.9
14	13½	48.9	13.6	743	110
16	15½	56.2	15.6	1125	145
18	17½	63.4	17.6	1619	185
6 x 6	5½x5½	30.3	8.40	76.3	27.7
8	7½	41.3	11.4	193	51.6
10	9½	52.3	14.5	393	82.7
12	11½	63.3	17.5	697	121
14	13½	74.3	20.6	1128	167
16	15½	85.3	23.6	1707	220
18	17½	96.3	26.7	2456	281
20	19½	107.3	29.8	3398	349
8 x 8	7½x7½	56.3	15.6	264	70.3
10	9½	71.3	19.8	536	113
12	11½	86.3	23.9	951	165
14	13½	101.3	28.0	1538	228
16	15½	116.3	32.0	2327	300
18	17½	131.3	36.4	3350	383
20	19½	146.3	40.6	4634	475
22	21½	161.3	44.8	6211	578

Nominal Size	American Standard Dressed Size	Area of Section	Weight per Foot	Moment of Inertia	Section Modulus
In.	In.	In.²	Lb.	In.⁴	In.³
10x10	9½x9½	90.3	25.0	679	143
12	11½	109	30.3	1204	209
14	13½	128	35.6	1948	289
16	15½	147	40.9	2948	380
18	17½	166	46.1	4243	485
20	19½	185	51.4	5870	602
22	21½	204	56.7	7868	732
24	23½	223	62.0	10274	874
12x12	11½x11½	132	36.7	1458	253
14	13½	155	43.1	2358	349
16	15½	178	49.5	3569	460
18	17½	201	55.9	5136	587
20	19½	224	62.3	7106	729
22	21½	247	68.7	9524	886
24	23½	270	75.0	12437	1058
14x14	13½x13½	182	50.6	2768	410
16	15½	209	58.1	4189	541
18	17½	236	65.6	6029	689
20	19½	263	73.1	8342	856
22	21½	290	80.6	11181	1040
24	23½	317	88.1	14600	1243
16x16	15½x15½	240	66.7	4810	621
18	17½	271	75.3	6923	791
20	19½	302	83.9	9578	982
22	21½	333	92.5	12837	1194
24	23½	364	101	16763	1427
18x18	17½x17½	306	85.0	7816	893
20	19½	341	94.8	10813	1109
22	21½	376	105	14493	1348
24	23½	411	114	18926	1611
26	25½	446	124	24181	1897
20x20	19½x19½	380	106	12049	1236
22	21½	419	116	16150	1502
24	23½	458	127	21089	1795
26	25½	497	138	26945	2113
28	27½	536	149	33795	2458
24x24	23½x23½	552	153	25415	2163
26	25½	599	166	32472	2547
28	27½	646	180	40727	2962
30	29½	693	193	50275	3408

All properties and weights given are for dressed size only.
The weights given above are based on assumed average weight of 40 pounds per cubic foot.

PROPERTIES OF THE CIRCLE



Circumference $= 6.28318\ r = 3.14159\ d$

Diameter $= 0.31831$ circumference

Area $= 3.14159\ r^2$

Arc $\quad a = \dfrac{\pi r A^\circ}{180^\circ} = 0.017453\ r A^\circ$

Angle $\quad A^\circ = \dfrac{180^\circ a}{\pi r} = 57.29578\ \dfrac{a}{r}$

Radius $r = \dfrac{4 b^2 + c^2}{8 b}$

Chord $\quad c = 2\sqrt{2 br - b^2} = 2 r \sin \dfrac{A}{2}$

Rise $\quad b = r - \tfrac{1}{2}\sqrt{4 r^2 - c^2} = \dfrac{c}{2} \tan \dfrac{A}{4}$

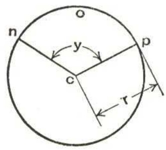
$\qquad = 2 r \sin^2 \dfrac{A}{4} = r + y - \sqrt{r^2 - x^2}$

$\qquad y = b - r + \sqrt{r^2 - x^2}$

$\qquad x = \sqrt{r^2 - (r + y - b)^2}$

Diameter of circle of equal periphery as square = 1.27324 side of square
Side of square of equal periphery as circle = 0.78540 diameter of circle
Diameter of circle circumscribed about square = 1.41421 side of square
Side of square inscribed in circle = 0.70711 diameter of circle

CIRCULAR SECTOR



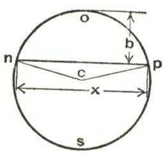
r = radius of circle $\qquad$ y = angle ncp in degrees

Area of Sector ncpo = ½ (length of arc nop × r)

$= \text{Area of Circle} \times \dfrac{y}{360}$

$= 0.0087266 \times r^2 \times y$

CIRCULAR SEGMENT



r = radius of circle $\qquad$ x = chord $\qquad$ b = rise

Area of Segment nop = Area of Sector ncpo — Area of triangle ncp

$= \dfrac{(\text{Length of arc nop} \times r) - x\,(r - b)}{2}$

Area of Segment nsp = Area of Circle — Area of Segment nop

VALUES FOR FUNCTIONS OF π

$\pi = 3.14159265359$, $\quad \log = 0.4971499$

$\pi^2 = 9.8696044$, $\log = 0.9942997$	$\dfrac{1}{\pi} = 0.3183099$, $\log = \bar{1}.5028501$	$\sqrt{\dfrac{1}{\pi}} = 0.5641896$, $\log = \bar{1}.7514251$
$\pi^3 = 31.0062767$, $\log = 1.4914496$	$\dfrac{1}{\pi^2} = 0.1013212$, $\log = \bar{1}.0057003$	$\dfrac{\pi}{180} = 0.0174533$, $\log = \bar{2}.2418774$
$\sqrt{\pi} = 1.7724539$, $\log = 0.2485749$	$\dfrac{1}{\pi^3} = 0.0322515$, $\log = \bar{2}.5085500$	$\dfrac{180}{\pi} = 57.2957795$, $\log = 1.7581226$

LENGTH OF CIRCULAR ARCS FOR UNIT RADIUS

By the use of this table, the length of any arc may be found if the length of the radius and the angle of the segment are known.

Example:—Required the length of arc of segment 32° 15′ 27″ with radius of 24 feet 3 inches.

From table: Length of arc (Radius 1) for 32° = .5585054

15′ = .0043633

27″ = .0001309

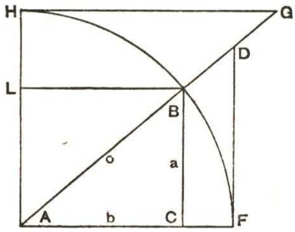
.5629996

.5629996 × 24.25 (length of radius) = 13.65 feet

DEGREES						MINUTES		SECONDS	
1	.017 4533	61	1.064 6508	121	2.111 8484	1	.000 2909	1	.000 0048
2	.034 9066	62	1.082 1041	122	2.129 3017	2	.000 5818	2	.000 0097
3	.052 3599	63	1.099 5574	123	2.146 7550	3	.000 8727	3	.000 0145
4	.069 8132	64	1.117 0107	124	2.164 2083	4	.001 1636	4	.000 0194
5	.087 2665	65	1.134 4640	125	2.181 6616	5	.001 4544	5	.000 0242
6	.104 7198	66	1.151 9173	126	2.199 1149	6	.001 7453	6	.000 0291
7	.122 1730	67	1.169 3706	127	2.216 5682	7	.002 0362	7	.000 0339
8	.139 6263	68	1.186 8239	128	2.234 0214	8	.002 3271	8	.000 0388
9	.157 0796	69	1.204 2772	129	2.251 4747	9	.002 6180	9	.000 0436
10	.174 5329	70	1 221 7305	130	2.268 9280	10	.002 9089	10	.000 0485
11	.191 9862	71	1.239 1838	131	2.286 3813	11	.003 1998	11	.000 0533
12	.209 4395	72	1.256 6371	132	2.303 8346	12	.003 4907	12	.000 0582
13	.226 8928	73	1.274 0904	133	2.321 2879	13	.003 7815	13	.000 0630
14	.244 3461	74	1.291 5436	134	2.338 7412	14	.004 0724	14	.000 0679
15	.261 7994	75	1.308 9969	135	2.356 1945	15	.004 3633	15	.000 0727
16	.279 2527	76	1.326 4502	136	2.373 6478	16	.004 6542	16	.000 0776
17	.296 7060	77	1.343 9035	137	2.391 1011	17	.004 9451	17	.000 0824
18	.314 1593	78	1.361 3568	138	2.408 5544	18	.005 2360	18	.000 0873
19	.331 6126	79	1.378 8101	139	2.426 0077	19	.005 5269	19	.000 0921
20	.349 0659	80	1.396 2634	140	2.443 4610	20	.005 8178	20	.000 0970
21	.366 5191	81	1.413 7167	141	2.460 9142	21	.006 1087	21	.000 1018
22	.383 9724	82	1.431 1700	142	2.478 3675	22	.006 3995	22	.000 1067
23	.401 4257	83	1.448 6233	143	2.495 8208	23	.006 6904	23	.000 1115
24	.418 8790	84	1.466 0766	144	2.513 2741	24	.006 9813	24	.000 1164
25	.436 3323	85	1.483 5299	145	2.530 7274	25	.007 2722	25	.000 1212
26	.453 7856	86	1.500 9832	146	2.548 1807	26	.007 5631	26	.000 1261
27	.471 2389	87	1.518 4364	147	2.565 6340	27	.007 8540	27	.000 1309
28	.488 6922	88	1.535 8897	148	2.583 0873	28	.008 1449	28	.000 1357
29	.506 1455	89	1.553 3430	149	2.600 5406	29	.008 4358	29	.000 1406
30	.523 5988	90	1.570 7963	150	2.617 9939	30	.008 7266	30	.000 1454
31	.541 0521	91	1.588 2496	151	2.635 4472	31	.009 0175	31	.000 1503
32	.558 5054	92	1.605 7029	152	2.652 9005	32	.009 3084	32	.000 1551
33	.575 9587	93	1.623 1562	153	2.670 3538	33	.009 5993	33	.000 1600
34	.593 4119	94	1.640 6095	154	2.687 8070	34	.009 8902	34	.000 1648
35	.610 8652	95	1.658 0628	155	2.705 2603	35	.010 1811	35	.000 1697
36	.628 3185	96	1.675 5161	156	2.722 7136	36	.010 4720	36	.000 1745
37	.645 7718	97	1.692 9694	157	2.740 1669	37	.010 7629	37	.000 1794
38	.663 2251	98	1.710 4227	158	2.757 6202	38	.011 0538	38	.000 1842
39	.680 6784	99	1.727 8760	159	2.775 0735	39	.011 3446	39	.000 1891
40	.698 1317	100	1.745 3293	160	2.792 5268	40	.011 6355	40	.000 1939
41	.715 5850	101	1.762 7825	161	2.809 9801	41	.011 9264	41	.000 1988
42	.733 0383	102	1.780 2358	162	2.827 4334	42	.012 2173	42	.000 2036
43	.750 4916	103	1.797 6891	163	2.844 8867	43	.012 5082	43	.000 2085
44	.767 9449	104	1.815 1424	164	2.862 3400	44	.012 7991	44	.000 2133
45	.785 3982	105	1.832 5957	165	2.879 7933	45	.013 0900	45	.000 2182
46	.802 8515	106	1.850 0490	166	2.897 2466	46	.013 3809	46	.000 2230
47	.820 3047	107	1.867 5023	167	2.914 6999	47	.013 6717	47	.000 2279
48	.837 7580	108	1.884 9556	168	2.932 1531	48	.013 9626	48	.000 2327
49	.855 2113	109	1.902 4089	169	2.949 6064	49	.014 2535	49	.000 2376
50	.872 6646	110	1.919 8622	170	2.967 0597	50	.014 5444	50	.000 2424
51	.890 1179	111	1.937 3155	171	2.984 5130	51	.014 8353	51	.000 2473
52	.907 5712	112	1.954 7688	172	3.001 9663	52	.015 1262	52	.000 2521
53	.925 0245	113	1.972 2221	173	3.019 4196	53	.015 4171	53	.000 2570
54	.942 4778	114	1.989 6753	174	3.036 8729	54	.015 7080	54	.000 2618
55	.959 9311	115	2.007 1286	175	3.054 3262	55	.015 9989	55	.000 2666
56	.977 3844	116	2.024 5819	176	3.071 7795	56	.016 2897	56	.000 2715
57	.994 8377	117	2.042 0352	177	3.089 2328	57	.016 5806	57	.000 2763
58	1.012 2910	118	2.059 4885	178	3.106 6861	58	.016 8715	58	.000 2812
59	1.029 7443	119	2.076 9418	179	3.124 1394	59	.017 1624	59	.000 2860
60	1.047 1976	120	2.094 3951	180	3.141 5927	60	.017 4533	60	.000 2909

TRIGONOMETRIC FORMULAS

TRIGONOMETRIC FUNCTIONS



$$\text{Radius AF} = 1 = \sin^2 A + \cos^2 A = \sin A \operatorname{cosec} A = \cos A \sec A = \tan A \cot A$$

$$\text{Sine A} = \frac{\cos A}{\cot A} = \frac{1}{\operatorname{cosec} A} = \cos A \tan A = \sqrt{1-\cos^2 A} = BC$$

$$\text{Cosine A} = \frac{\sin A}{\tan A} = \frac{1}{\sec A} = \sin A \cot A = \sqrt{1-\sin^2 A} = AC$$

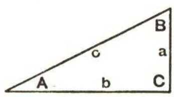
$$\text{Tangent A} = \frac{\sin A}{\cos A} = \frac{1}{\cot A} = \sin A \sec A = FD$$

$$\text{Cotangent A} = \frac{\cos A}{\sin A} = \frac{1}{\tan A} = \cos A \operatorname{cosec} A = HG$$

$$\text{Secant A} = \frac{\tan A}{\sin A} = \frac{1}{\cos A} = AD$$

$$\text{Cosecant A} = \frac{\cot A}{\cos A} = \frac{1}{\sin A} = AG$$

RIGHT ANGLED TRIANGLES



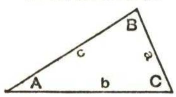
$$a^2 = c^2 - b^2$$

$$b^2 = c^2 - a^2$$

$$c^2 = a^2 + b^2$$

Known	Required A	B	a	b	c	Area
a, b	$\tan A = \frac{a}{b}$	$\tan B = \frac{b}{a}$			$\sqrt{a^2+b^2}$	$\frac{ab}{2}$
a, c	$\sin A = \frac{a}{c}$	$\cos B = \frac{a}{c}$		$\sqrt{c^2-a^2}$		$\frac{a\sqrt{c^2-a^2}}{2}$
A, a		$90° - A$		$a \cot A$	$\frac{a}{\sin A}$	$\frac{a^2 \cot A}{2}$
A, b		$90° - A$	$b \tan A$		$\frac{b}{\cos A}$	$\frac{b^2 \tan A}{2}$
A, c		$90° - A$	$c \sin A$	$c \cos A$		$\frac{c^2 \sin 2A}{4}$

OBLIQUE ANGLED TRIANGLES



$$s = \frac{a+b+c}{2}$$

$$K = \sqrt{\frac{(s-a)(s-b)(s-c)}{s}}$$

$$a^2 = b^2 + c^2 - 2\,bc \cos A$$

$$b^2 = a^2 + c^2 - 2\,ac \cos B$$

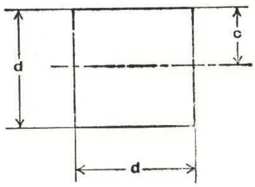
$$c^2 = a^2 + b^2 - 2\,ab \cos C$$

Known	Required A	B	C	b	c	Area
a, b, c	$\tan \frac{1}{2} A = \frac{K}{s-a}$	$\tan \frac{1}{2} B = \frac{K}{s-b}$	$\tan \frac{1}{2} C = \frac{K}{s-c}$			$\sqrt{s(s-a)(s-b)(s-c)}$
a, A, B			$180° - (A+B)$	$\frac{a \sin B}{\sin A}$	$\frac{a \sin C}{\sin A}$	
a, b, A		$\sin B = \frac{b \sin A}{a}$			$\frac{b \sin C}{\sin B}$	
a, b, C	$\tan A = \frac{a \sin C}{b - a \cos C}$				$\sqrt{a^2+b^2-2ab \cos C}$	$\frac{ab \sin C}{2}$

PROPERTIES OF GEOMETRIC SECTIONS

SQUARE

Axis of moments through center



$A = d^2$

$c = \frac{d}{2}$

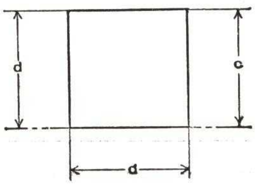
$I = \frac{d^4}{12}$

$S = \frac{d^3}{6}$

$r = \frac{d}{\sqrt{12}} = .288675\ d$

SQUARE

Axis of moments on base



$A = d^2$

$c = d$

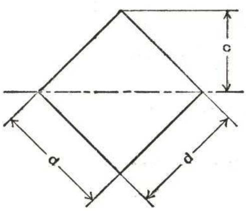
$I = \frac{d^4}{3}$

$S = \frac{d^3}{3}$

$r = \frac{d}{\sqrt{3}} = .577350\ d$

SQUARE

Axis of moments on diagonal



$A = d^2$

$c = \frac{d}{\sqrt{2}} = .707107\ d$

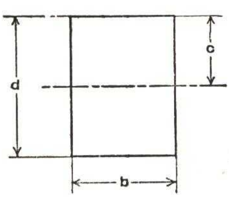
$I = \frac{d^4}{12}$

$S = \frac{d^3}{6\sqrt{2}} = .117851\ d^3$

$r = \frac{d}{\sqrt{12}} = .288675\ d$

RECTANGLE

Axis of moments through center



$A = bd$

$c = \frac{d}{2}$

$I = \frac{bd^3}{12}$

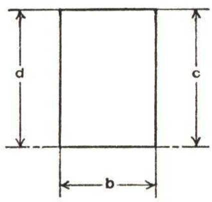
$S = \frac{bd^2}{6}$

$r = \frac{d}{\sqrt{12}} = .288675\ d$

PROPERTIES OF GEOMETRIC SECTIONS

RECTANGLE

Axis of moments on base



$$A = bd$$

$$c = d$$

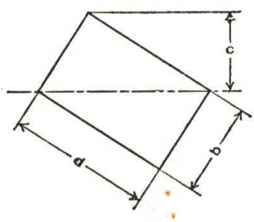
$$I = \frac{bd^3}{3}$$

$$S = \frac{bd^2}{3}$$

$$r = \frac{d}{\sqrt{3}} = .577350\ d$$

RECTANGLE

Axis of moments on diagonal



$$A = bd$$

$$c = \frac{bd}{\sqrt{b^2 + d^2}}$$

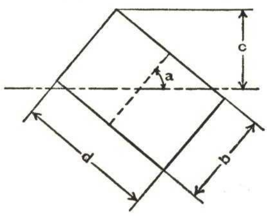
$$I = \frac{b^3d^3}{6\,(b^2 + d^2)}$$

$$S = \frac{b^2d^2}{6\sqrt{b^2 + d^2}}$$

$$r = \frac{bd}{\sqrt{6\,(b^2 + d^2)}}$$

RECTANGLE

Axis of moments any line through center of gravity



$$A = bd$$

$$c = \frac{b \sin a + d \cos a}{2}$$

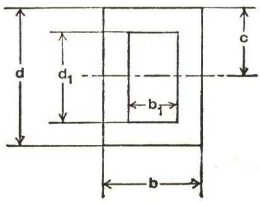
$$I = \frac{bd\,(b^2 \sin^2 a + d^2 \cos^2 a)}{12}$$

$$S = \frac{bd\,(b^2 \sin^2 a + d^2 \cos^2 a)}{6\,(b \sin a + d \cos a)}$$

$$r = \sqrt{\frac{b^2 \sin^2 a + d^2 \cos^2 a}{12}}$$

HOLLOW RECTANGLE

Axis of moments through center



$$A = bd - b_1d_1$$

$$c = \frac{d}{2}$$

$$I = \frac{bd^3 - b_1d_1^3}{12}$$

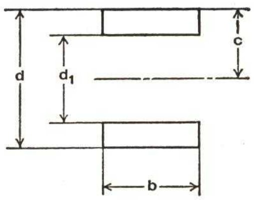
$$S = \frac{bd^3 - b_1d_1^3}{6d}$$

$$r = \sqrt{\frac{bd^3 - b_1d_1^3}{12\,A}}$$

PROPERTIES OF GEOMETRIC SECTIONS

EQUAL RECTANGLES

Axis of moments through center of gravity



$$A = b(d - d_1)$$

$$c = \frac{d}{2}$$

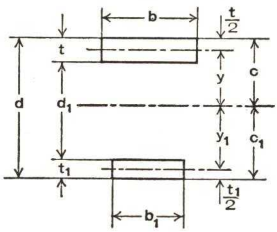
$$I = \frac{b(d^3 - d_1^3)}{12}$$

$$S = \frac{b(d^3 - d_1^3)}{6d}$$

$$r = \sqrt{\frac{d^3 - d_1^3}{12(d - d_1)}}$$

UNEQUAL RECTANGLES

Axis of moments through center of gravity



$$A = bt + b_1t_1$$

$$c = \frac{\frac{1}{2}bt^2 + b_1t_1(d - \frac{1}{2}t_1)}{A}$$

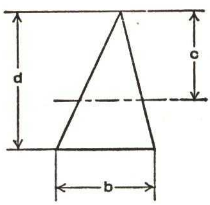
$$I = \frac{bt^3}{12} + bty^2 + \frac{b_1t_1^3}{12} + b_1t_1y_1^2$$

$$S = \frac{I}{c} \qquad S_1 = \frac{I}{c_1}$$

$$r = \sqrt{\frac{I}{A}}$$

TRIANGLE

Axis of moments through center of gravity



$$A = \frac{bd}{2}$$

$$c = \frac{2d}{3}$$

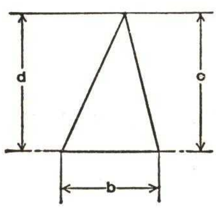
$$I = \frac{bd^3}{36}$$

$$S = \frac{bd^2}{24}$$

$$r = \frac{d}{\sqrt{18}} = .235702\ d$$

TRIANGLE

Axis of moments on base



$$A = \frac{bd}{2}$$

$$c = d$$

$$I = \frac{bd^3}{12}$$

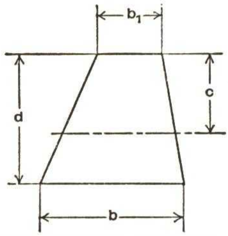
$$S = \frac{bd^2}{12}$$

$$r = \frac{d}{\sqrt{6}} = .408248\ d$$

PROPERTIES OF GEOMETRIC SECTIONS

TRAPEZOID

Axis of moments through center of gravity



$$A = \frac{d(b + b_1)}{2}$$

$$c = \frac{d(2b + b_1)}{3(b + b_1)}$$

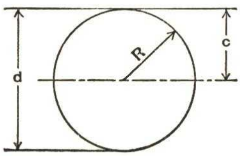
$$I = \frac{d^3\,(b^2 + 4\,bb_1 + b_1{}^2)}{36\,(b + b_1)}$$

$$S = \frac{d^2\,(b^2 + 4\,bb_1 + b_1{}^2)}{12\,(2b + b_1)}$$

$$r = \frac{d}{6(b + b_1)}\sqrt{2\,(b^2 + 4\,bb_1 + b_1{}^2)}$$

CIRCLE

Axis of moments through center



$$A = \frac{\pi d^2}{4} = \pi R^2 = .785398\ d^2 = 3.141593\ R^2$$

$$c = \frac{d}{2} = R$$

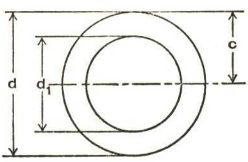
$$I = \frac{\pi d^4}{64} = \frac{\pi R^4}{4} = .049087\ d^4 = .785398\ R^4$$

$$S = \frac{\pi d^3}{32} = \frac{\pi R^3}{4} = .098175\ d^3 = .785398\ R^3$$

$$r = \frac{d}{4} = \frac{R}{2}$$

HOLLOW CIRCLE

Axis of moments through center



$$A = \frac{\pi(d^2 - d_1{}^2)}{4} = .785398\ (d^2 - d_1{}^2)$$

$$c = \frac{d}{2}$$

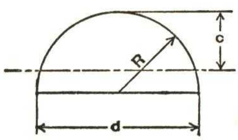
$$I = \frac{\pi(d^4 - d_1{}^4)}{64} = .049087\ (d^4 - d_1{}^4)$$

$$S = \frac{\pi(d^4 - d_1{}^4)}{32d} = .098175\ \frac{d^4 - d_1{}^4}{d}$$

$$r = \frac{\sqrt{d^2 + d_1{}^2}}{4}$$

HALF CIRCLE

Axis of moments through center of gravity



$$A = \frac{\pi R^2}{2} = 1.570796\ R^2$$

$$c = R\left(1 - \frac{4}{3\pi}\right) = .575587\ R$$

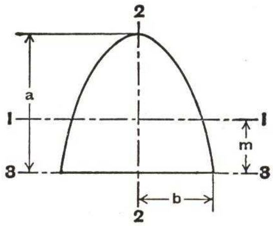
$$I = R^4\left(\frac{\pi}{8} - \frac{8}{9\pi}\right) = .109757\ R^4$$

$$S = \frac{R^3}{24}\ \frac{(9\pi^2 - 64)}{(3\pi - 4)} = .190687\ R^3$$

$$r = R\,\frac{\sqrt{9\pi^2 - 64}}{6\pi} = .264336\ R$$

PROPERTIES OF GEOMETRIC SECTIONS

PARABOLA



$A = \frac{4}{3} ab$

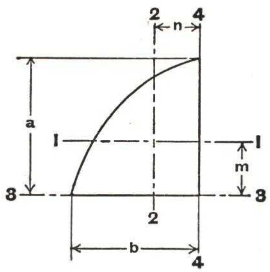
$m = \frac{2}{5} a$

$I_1 = \frac{16}{175} a^3 b$

$I_2 = \frac{4}{15} ab^3$

$I_3 = \frac{32}{105} a^3 b$

HALF PARABOLA



$A = \frac{2}{3} ab$

$m = \frac{2}{5} a$

$n = \frac{3}{8} b$

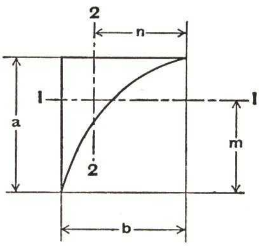
$I_1 = \frac{8}{175} a^3 b$

$I_2 = \frac{19}{480} ab^3$

$I_3 = \frac{16}{105} a^3 b$

$I_4 = \frac{2}{15} ab^3$

COMPLEMENT OF HALF PARABOLA



$A = \frac{1}{3} ab$

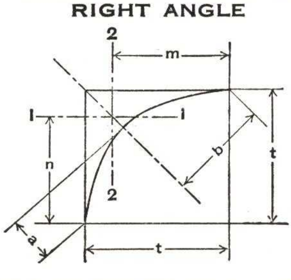
$m = \frac{7}{10} a$

$n = \frac{3}{4} b$

$I_1 = \frac{37}{2100} a^3 b$

$I_2 = \frac{1}{80} ab^3$

PARABOLIC FILLET IN RIGHT ANGLE



$a = \frac{t}{2\sqrt{2}}$

$b = \frac{t}{\sqrt{2}}$

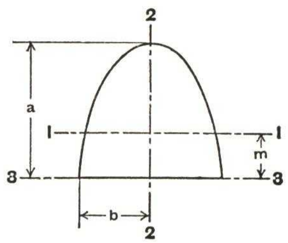
$A = \frac{1}{6} t^2$

$m = n = \frac{4}{5} t$

$I_1 = I_2 = \frac{11}{2100} t^4$

PROPERTIES OF GEOMETRIC SECTIONS

* HALF ELLIPSE



$$A = \frac{1}{2}\pi ab$$

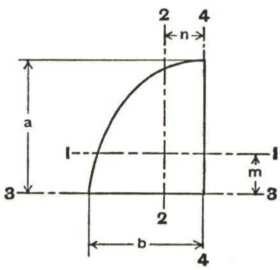
$$m = \frac{4a}{3\pi}$$

$$I_1 = a^3b\left(\frac{\pi}{8} - \frac{8}{9\pi}\right)$$

$$I_2 = \frac{1}{8}\pi ab^3$$

$$I_3 = \frac{1}{8}\pi a^3 b$$

* QUARTER ELLIPSE



$$A = \frac{1}{4}\pi ab$$

$$m = \frac{4a}{3\pi}$$

$$n = \frac{4b}{3\pi}$$

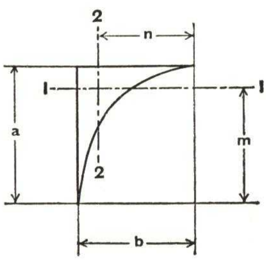
$$I_1 = a^3b\left(\frac{\pi}{16} - \frac{4}{9\pi}\right)$$

$$I_2 = ab^3\left(\frac{\pi}{16} - \frac{4}{9\pi}\right)$$

$$I_3 = \frac{1}{16}\pi a^3 b$$

$$I_4 = \frac{1}{16}\pi ab^3$$

* ELLIPTIC COMPLEMENT



$$A = ab\left(1 - \frac{\pi}{4}\right)$$

$$m = \frac{a}{6\left(1 - \frac{\pi}{4}\right)}$$

$$n = \frac{b}{6\left(1 - \frac{\pi}{4}\right)}$$

$$I_1 = a^3b\left(\frac{1}{3} - \frac{\pi}{16} - \frac{1}{36\left(1 - \frac{\pi}{4}\right)}\right)$$

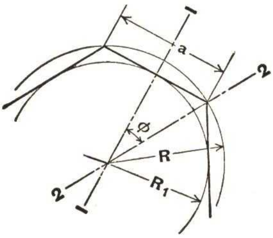
$$I_2 = ab^3\left(\frac{1}{3} - \frac{\pi}{16} - \frac{1}{36\left(1 - \frac{\pi}{4}\right)}\right)$$

* To obtain properties of half circle, quarter circle and circular complement substitute a = b = R.

PROPERTIES OF GEOMETRIC SECTIONS AND STRUCTURAL SHAPES

REGULAR POLYGON

Axis of moments through center



$$n = \text{Number of sides}$$

$$\phi = \frac{180°}{n}$$

$$a = 2\sqrt{R^2 - R_1^2}$$

$$R = \frac{a}{2\sin\phi}$$

$$R_1 = \frac{a}{2\tan\phi}$$

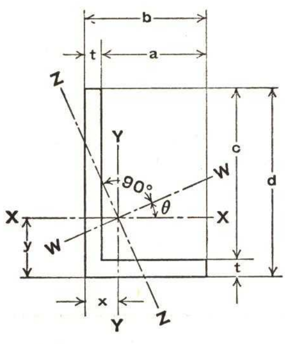
$$A = \frac{1}{4}na^2\cot\phi = \frac{1}{2}nR^2\sin 2\phi = nR_1^2\tan\phi$$

$$I_1 = I_2 = \frac{A(6R^2 - a^2)}{24} = \frac{A(12R_1^2 + a^2)}{48}$$

$$r_1 = r_2 = \sqrt{\frac{6R^2 - a^2}{24}} = \sqrt{\frac{12R_1^2 + a^2}{48}}$$

ANGLE

Axis of moments through center of gravity



Z-Z is axis of minimum I

$$\tan 2\theta = \frac{2K}{I_Y - I_X}$$

$$A = t(b + c) \quad x = \frac{b^2 + ct}{2(b + c)} \quad y = \frac{d^2 + at}{2(b + c)}$$

$$K = \text{Product of Inertia about X-X \& Y-Y}$$

$$= \mp\frac{abcdt}{4(b + c)}$$

$$I_X = \frac{1}{3}\left(t(d - y)^3 + by^3 - a(y - t)^3\right)$$

$$I_Y = \frac{1}{3}\left(t(b - x)^3 + dx^3 - c(x - t)^3\right)$$

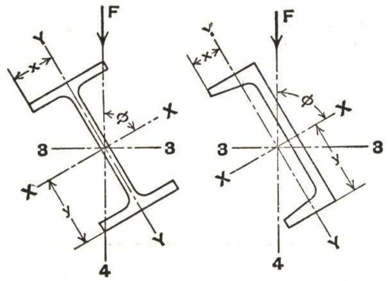
$$I_Z = I_X\sin^2\theta + I_Y\cos^2\theta + K\sin 2\theta$$

$$I_W = I_X\cos^2\theta + I_Y\sin^2\theta - K\sin 2\theta$$

K is negative when heel of angle, with respect to c. g., is in 1st or 3rd quadrant, positive when in 2nd or 4th quadrant.

BEAMS AND CHANNELS

Transverse force oblique through center of gravity



$$I_3 = I_X\sin^2\phi + I_Y\cos^2\phi$$

$$I_4 = I_X\cos^2\phi + I_Y\sin^2\phi$$

$$f = M\left(\frac{y}{I_X}\sin\phi + \frac{x}{I_Y}\cos\phi\right)$$

where M is bending moment due to force F.

MECHANICS OF MATERIALS

FREQUENTLY USED FORMULAS

The formulas given below are frequently required in structural designing. They are included herein for the convenience of those engineers who have infrequent use for such formulas and hence may find reference necessary. Variation from the standard nomenclature on page 6 is noted.

BEAMS

Flexural stress at extreme fiber:

$$f = Mc/I = M/S$$

Flexural stress at any fiber:

$f = My/I$ $\quad$ y = distance from neutral axis to fiber.

Average vertical shear (for maximum see below):

$v = V/A = V/dt$ (for beams and girders)

Horizontal shearing stress at any section A-A:

$v = VQ/I\,b$ $\quad$ Q = statical moment about the neutral axis of the entire section of that portion of the cross-section lying outside of section A-A,

b = width at section A-A

(Intensity of vertical shear is equal to that of horizontal shear acting normal to it at the same point and both are usually a maximum at mid-height of beam.)

Slope and deflection at any point:

$$EI\frac{d^2y}{dx^2} = M$$

x and y are abscissa and ordinate respectively of a point on the neutral axis, referred to axes of rectangular coordinates through a selected point of support.

(First integration gives slopes; second integration gives deflections. Constants of integration must be determined.)

CONTINUOUS BEAMS (THE THEOREM OF THREE MOMENTS)

Uniform load:

$$M_a\frac{l_1}{I_1} + 2M_b\left(\frac{l_1}{I_1} + \frac{l_2}{I_2}\right) + M_c\frac{l_2}{I_2} = -\frac{1}{4}\left(\frac{w_1 l_1^3}{I_1} + \frac{w_2 l_2^3}{I_2}\right)$$

Concentrated loads:

$$M_a\frac{l_1}{I_1} + 2M_b\left(\frac{l_1}{I_1} + \frac{l_2}{I_2}\right) + M_c\frac{l_2}{I_2} = -\frac{P_1a_1b_1}{I_1}\left(1 + \frac{a_1}{l_1}\right) - \frac{P_2a_2b_2}{I_2}\left(1 + \frac{b_2}{l_2}\right)$$

Considering any two consecutive spans in any continuous structure:

M_a, M_b, M_c = moments at left, center, and right supports respectively, of any pair of adjacent spans.

l_1 and l_2 = length of left and right spans respectively, of the pair.

I_1 and I_2 = moment of inertia of left and right spans respectively.

w_1 and w_2 = load per unit of length on left and right spans respectively.

P_1 and P_2 = concentrated loads on left and right spans respectively.

a_1 and a_2 = distance of concentrated loads from left support in left and right spans respectively.

b_1 and b_2 = distance of concentrated loads from right support in left and right spans respectively.

The above equations are for beams with moment of inertia constant in each span but differing in different spans, continuous over three or more supports. By writing such an equation for each successive pair of spans and introducing the known values (usually zero) of end moments, all other moments can be found.

COLUMNS

Concentrically loaded:

$$f = P/A$$

Eccentrically loaded:

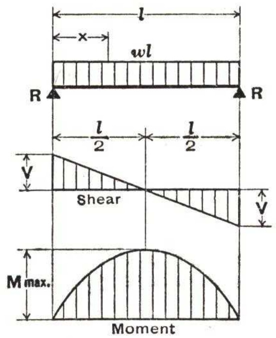
$f = P/A + Mc/I.$ Bending in plane of principal axis. Deflection not considered.

$= \frac{P}{A}(1 + ec/r^2)$ $\quad$ e = eccentricity of load.

BEAM DIAGRAMS AND FORMULAS
FOR VARIOUS STATIC LOADING CONDITIONS

Equivalent Tabular Load is the uniformly distributed load given in the beam tables, pages 175 to 201. For meaning of symbols, see page 6.

1. SIMPLE BEAM—UNIFORMLY DISTRIBUTED LOAD



Equivalent Tabular Load . . . $= wl$

R = V . . . . $= \frac{wl}{2}$

Vx . . . . $= w\left(\frac{l}{2} - x\right)$

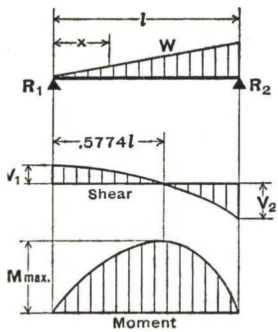
M max. (at center) . . . . . $= \frac{wl^2}{8}$

Mx . . . . $= \frac{wx}{2}(l - x)$

Δmax. (at center) . . . . $= \frac{5\,wl^4}{384\,EI}$

Δx . . . . $= \frac{wx}{24EI}(l^3 - 2lx^2 + x^3)$

2. SIMPLE BEAM—LOAD INCREASING UNIFORMLY TO ONE END



Equivalent Tabular Load . . . $= \frac{16W}{9\sqrt{3}} = 1.0264W$

$R_1 = V_1$ . . . . $= \frac{W}{3}$

$R_2 = V_2$ max. . . . . $= \frac{2W}{3}$

Vx . . . . $= \frac{W}{3} - \frac{Wx^2}{l^2}$

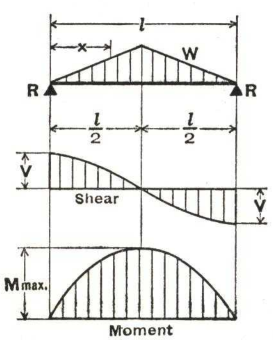
M max. $\left(\text{at } x = \frac{l}{\sqrt{3}} = .5774l\right)$ . . $= \frac{2Wl}{9\sqrt{3}} = .1283\,Wl$

Mx . . . . $= \frac{Wx}{3l^2}(l^2 - x^2)$

Δmax. $\left(\text{at } x = l\sqrt{1 - \sqrt{\frac{8}{15}}} = .5193l\right)$ $= .01304\,\frac{Wl^3}{EI}$

Δx . . . . $= \frac{Wx}{180EI\,l^2}(3x^4 - 10l^2x^2 + 7l^4)$

3. SIMPLE BEAM—LOAD INCREASING UNIFORMLY TO CENTER



Equivalent Tabular Load . . . $= \frac{4W}{3}$

R = V . . . . $= \frac{W}{2}$

Vx $\left(\text{when } x < \frac{l}{2}\right)$ . . . . $= \frac{W}{2l^2}(l^2 - 4x^2)$

M max. (at center) . . . . $= \frac{Wl}{6}$

Mx $\left(\text{when } x < \frac{l}{2}\right)$ . . . . $= Wx\left(\frac{1}{2} - \frac{2x^2}{3l^2}\right)$

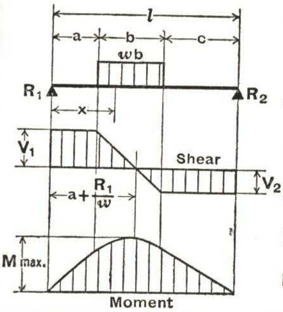
Δmax. (at center) . . . . $= \frac{Wl^3}{60EI}$

Δx . . . . $= \frac{Wx}{480\,EI\,l^2}(5l^2 - 4x^2)^2$

BEAM DIAGRAMS AND FORMULAS
FOR VARIOUS STATIC LOADING CONDITIONS

For meaning of symbols, see page 6.

4. SIMPLE BEAM—UNIFORM LOAD PARTIALLY DISTRIBUTED



$R_1 = V_1 \left(\text{max. when } a < c\right) \quad . \quad . \quad = \frac{wb}{2l}(2c + b)$

$R_2 = V_2 \left(\text{max. when } a > c\right) \quad . \quad . \quad = \frac{wb}{2l}(2a + b)$

$V_x \left(\text{when } x > a \text{ and } < (a + b)\right) \quad . \quad = R_1 - w(x - a)$

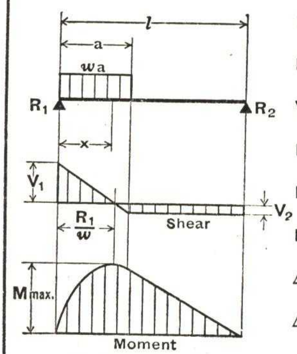
$M \text{ max.} \left(\text{at } x = a + \frac{R_1}{w}\right) \quad . \quad . \quad . \quad . \quad = R_1\left(a + \frac{R_1}{2w}\right)$

$M_x \left(\text{when } x < a\right) \quad . \quad . \quad . \quad . \quad . \quad = R_1 x$

$M_x \left(\text{when } x > a \text{ and } < (a + b)\right) \quad . \quad = R_1 x - \frac{w}{2}(x - a)^2$

$M_x \left(\text{when } x > (a + b)\right) \quad . \quad . \quad . \quad . \quad = R_2 (l - x)$

5. SIMPLE BEAM—UNIFORM LOAD PARTIALLY DISTRIBUTED AT ONE END



$R_1 = V_1 \text{ max.} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad = \frac{wa}{2l}(2l - a)$

$R_2 = V_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad = \frac{wa^2}{2l}$

$V \left(\text{when } x < a\right) \quad . \quad . \quad . \quad . \quad = R_1 - wx$

$M \text{ max.} \left(\text{at } x = \frac{R_1}{w}\right) \quad . \quad . \quad . \quad . \quad . \quad = \frac{R_1^2}{2w}$

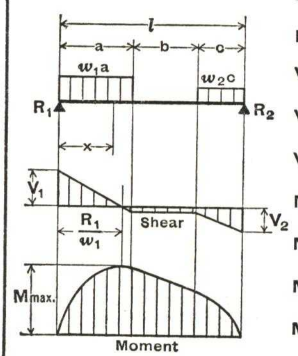
$M_x \left(\text{when } x < a\right) \quad . \quad . \quad . \quad . \quad . \quad = R_1 x - \frac{wx^2}{2}$

$M_x \left(\text{when } x > a\right) \quad . \quad . \quad . \quad . \quad . \quad = R_2 (l - x)$

$\Delta x \left(\text{when } x < a\right) \quad . \quad . \quad . \quad . \quad . \quad = \frac{wx}{24EIl}\left(a^2(2l - a)^2 - 2ax^2(2l - a) + lx^3\right)$

$\Delta x \left(\text{when } x > a\right) \quad . \quad . \quad . \quad . \quad . \quad = \frac{wa^2(l - x)}{24EIl}(4xl - 2x^2 - a^2)$

6. SIMPLE BEAM—UNIFORM LOAD PARTIALLY DISTRIBUTED AT EACH END



$R_1 = V_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad = \frac{w_1 a(2l - a) + w_2 c^2}{2l}$

$R_2 = V_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad = \frac{w_2 c(2l - c) + w_1 a^2}{2l}$

$V_x \left(\text{when } x < a\right) \quad . \quad . \quad . \quad . \quad = R_1 - w_1 x$

$V_x \left(\text{when } x > a \text{ and } < (a + b)\right) \quad . \quad = R_1 - R_2$

$V_x \left(\text{when } x > (a + b)\right) \quad . \quad . \quad . \quad . \quad = R_2 - w_2(l - x)$

$M \text{ max.} \left(\text{at } x = \frac{R_1}{w_1} \text{ when } R_1 < w_1 a\right) \quad . \quad = \frac{R_1^2}{2w_1}$

$M \text{ max.} \left(\text{at } x = l - \frac{R_2}{w_2} \text{ when } R_2 < w_2 c\right) = \frac{R_2^2}{2w_2}$

$M_x \left(\text{when } x < a\right) \quad . \quad . \quad . \quad . \quad . \quad = R_1 x - \frac{w_1 x^2}{2}$

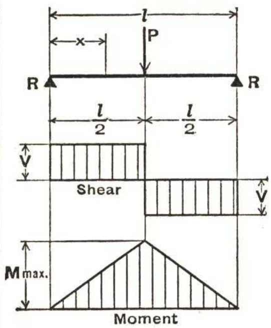
$M_x \left(\text{when } x > a \text{ and } < (a + b)\right) \quad . \quad = R_1 x - \frac{w_1 a}{2}(2x - a)$

$M_x \left(\text{when } x > (a + b)\right) \quad . \quad . \quad . \quad . \quad = R_2 (l - x) - \frac{w_2 (l - x)^2}{2}$

BEAM DIAGRAMS AND FORMULAS
FOR VARIOUS STATIC LOADING CONDITIONS

Equivalent Tabular Load is the uniformly distributed load given in the beam tables, pages 175 to 201.
For meaning of symbols, see page 6.

7. SIMPLE BEAM—CONCENTRATED LOAD AT CENTER



Equivalent Tabular Load . . . . . . $= 2P$

$R = V$ . . . . $= \frac{P}{2}$

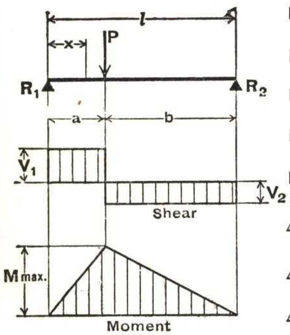
M max. (at point of load) . . . . . . $= \frac{Pl}{4}$

M_x $\left(\text{when } x < \frac{l}{2}\right)$ . . . . . . $= \frac{Px}{2}$

Δmax. (at point of load) . . . . . . $= \frac{Pl^3}{48EI}$

Δx $\left(\text{when } x < \frac{l}{2}\right)$ . . . . . . $= \frac{Px}{48EI}(3l^2 - 4x^2)$

8. SIMPLE BEAM—CONCENTRATED LOAD AT ANY POINT



Equivalent Tabular Load . . . . . . $= \frac{8\,Pab}{l^2}$

$R_1 = V_1$ (max. when $a < b$) . . . . $= \frac{Pb}{l}$

$R_2 = V_2$ (max. when $a > b$) . . . . $= \frac{Pa}{l}$

M max. (at point of load) . . . . $= \frac{Pab}{l}$

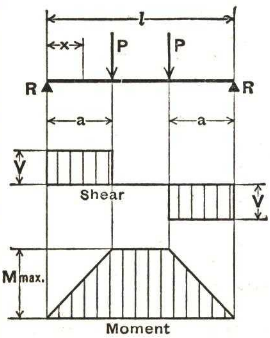
M_x (when $x < a$) . . . . $= \frac{Pbx}{l}$

Δmax. $\left(\text{at } x = \sqrt{\frac{a(a+2b)}{3}} \text{ when } a > b\right)$ $= \frac{Pab\,(a+2b)\sqrt{3a\,(a+2b)}}{27\,EI\,l}$

Δa (at point of load) . . . . $= \frac{Pa^2b^2}{3EI\,l}$

Δx (when $x < a$) . . . . $= \frac{Pbx}{6EI\,l}(l^2 - b^2 - x^2)$

9. SIMPLE BEAM—TWO EQUAL CONCENTRATED LOADS SYMMETRICALLY PLACED



Equivalent Tabular Load . . . . . . $= \frac{8\,Pa}{l}$

$R = V$ . . . . $= P$

M max. (between loads) . . . . . . $= Pa$

M_x (when $x < a$) . . . . $= Px$

Δmax. (at center) . . . . $= \frac{Pa}{24EI}(3l^2 - 4a^2)$

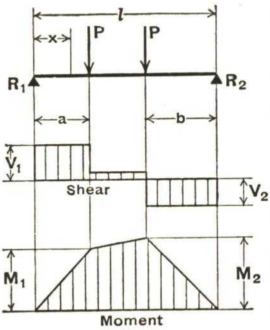
Δx (when $x < a$) . . . . $= \frac{Px}{6EI}(3la - 3a^2 - x^2)$

Δx (when $x > a$ and $< (l - a)$) . . $= \frac{Pa}{6EI}(3lx - 3x^2 - a^2)$

BEAM DIAGRAMS AND FORMULAS
FOR VARIOUS STATIC LOADING CONDITIONS

Equivalent Tabular Load is the uniformly distributed load given in the beam tables, pages 175 to 201. For meaning of symbols, see page 6.

10. SIMPLE BEAM—TWO EQUAL CONCENTRATED LOADS UNSYMMETRICALLY PLACED



$R_1 = V_1 \left(\text{max. when } a < b\right)$ . . . . $= \frac{P}{l}(l - a + b)$

$R_2 = V_2 \left(\text{max. when } a > b\right)$ . . . . $= \frac{P}{l}(l - b + a)$

$V_x \quad \left(\text{when } x > a \text{ and } < (l - b)\right)$ . . $= \frac{P}{l}(b - a)$

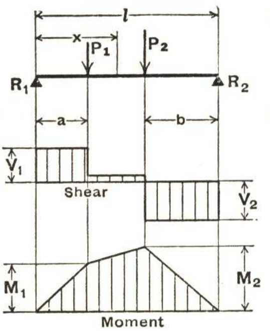
$M_1 \quad \left(\text{max. when } a > b\right)$ . . . . $= R_1 a$

$M_2 \quad \left(\text{max. when } a < b\right)$ . . . . $= R_2 b$

$M_x \quad \left(\text{when } x < a\right)$ . . . . $= R_1 x$

$M_x \quad \left(\text{when } x > a \text{ and } < (l - b)\right)$ . . $= R_1 x - P(x - a)$

11. SIMPLE BEAM—TWO UNEQUAL CONCENTRATED LOADS UNSYMMETRICALLY PLACED



$R_1 = V_1$ . . . . $= \dfrac{P_1(l - a) + P_2 b}{l}$

$R_2 = V_2$ . . . . $= \dfrac{P_1 a + P_2(l - b)}{l}$

$V_x \quad \left(\text{when } x > a \text{ and } < (l - b)\right)$ . . $= R_1 - P_1$

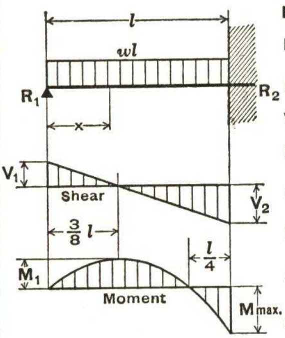
$M_1 \quad \left(\text{max. when } R_1 < P_1\right)$ . . . $= R_1 a$

$M_2 \quad \left(\text{max. when } R_2 < P_2\right)$ . . . $= R_2 b$

$M_x \quad \left(\text{when } x < a\right)$ . . . . $= R_1 x$

$M_x \quad \left(\text{when } x > a \text{ and } < (l - b)\right)$ . . $= R_1 x - P_1(x - a)$

12. BEAM FIXED AT ONE END, SUPPORTED AT OTHER—UNIFORMLY DISTRIBUTED LOAD



Equivalent Tabular Load . . . . . $= wl$

$R_1 = V_1$ . . . . $= \dfrac{3wl}{8}$

$R_2 = V_2$ max. . . . . $= \dfrac{5wl}{8}$

V_x . . . . $= R_1 - wx$

M max. . . . . $= \dfrac{wl^2}{8}$

$M_1 \quad \left(\text{at } x = \frac{3}{8} l\right)$ . . . . $= \dfrac{9}{128} wl^2$

M_x . . . . $= R_1 x - \dfrac{wx^2}{2}$

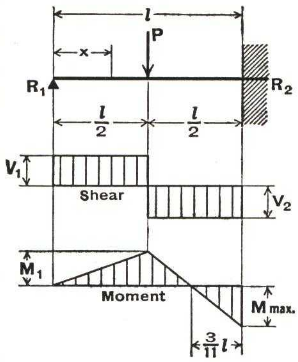
$\Delta\text{max.} \quad \left(\text{at } x = \frac{l}{16}(1 + \sqrt{33}) = .4215l\right)$. $= \dfrac{wl^4}{185EI}$

Δx . . . . $= \dfrac{wx}{48EI}(l^3 - 3lx^2 + 2x^3)$

BEAM DIAGRAMS AND FORMULAS
FOR VARIOUS STATIC LOADING CONDITIONS

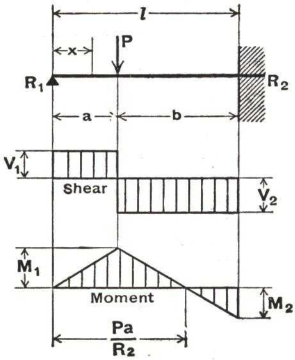
Equivalent Tabular Load is the uniformly distributed load given in the beam tables, pages 175 to 201. For meaning of symbols, see page 6.

13. BEAM FIXED AT ONE END, SUPPORTED AT OTHER— CONCENTRATED LOAD AT CENTER



Equivalent Tabular Load	$= \dfrac{3P}{2}$
$R_1 = V_1$	$= \dfrac{5P}{16}$
$R_2 = V_2$ max.	$= \dfrac{11P}{16}$
M max. (at fixed end)	$= \dfrac{3Pl}{16}$
M_1 (at point of load)	$= \dfrac{5Pl}{32}$
M_x $\left(\text{when } x < \dfrac{l}{2}\right)$	$= \dfrac{5Px}{16}$
M_x $\left(\text{when } x > \dfrac{l}{2}\right)$	$= P\left(\dfrac{l}{2} - \dfrac{11x}{16}\right)$
Δmax. $\left(\text{at } x = l\sqrt{\dfrac{1}{5}} = .4472l\right)$ . . .	$= \dfrac{Pl^3}{48EI\sqrt{5}} = .009317\dfrac{Pl^3}{EI}$
Δx (at point of load)	$= \dfrac{7Pl3}{768EI}$
Δx $\left(\text{when } x < \dfrac{l}{2}\right)$	$= \dfrac{Px}{96EI}(3l^2 - 5x^2)$
Δx $\left(\text{when } x > \dfrac{l}{2}\right)$	$= \dfrac{P}{96EI}(x - l)^2(11x - 2l)$

14. BEAM FIXED AT ONE END, SUPPORTED AT OTHER— CONCENTRATED LOAD AT ANY POINT

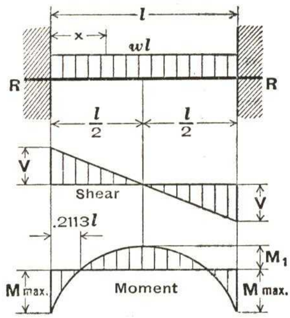


$R_1 = V_1$	$= \dfrac{Pb^2}{2l^3}(a + 2l)$
$R_2 = V_2$	$= \dfrac{Pa}{2l^3}(3l^2 - a^2)$
M_1 (at point of load)	$= R_1 a$
M_2 (at fixed end)	$= \dfrac{Pab}{2l^2}(a + l)$
M_x (when $x < a$)	$= R_1 x$
M_x (when $x > a$)	$= R_1 x - P(x - a)$
Δmax. $\left(\text{when } a < .414l \text{ at } x = l\dfrac{l^2+a^2}{3l^2-a^2}\right)$	$= \dfrac{Pa}{3EI}\dfrac{(l^2 - a^2)^3}{(3l^2 - a^2)^2}$
Δmax. $\left(\text{when } a > .414l \text{ at } x = l\sqrt{\dfrac{a}{2l+a}}\right)$	$= \dfrac{Pab^2}{6EI}\sqrt{\dfrac{a}{2l + a}}$
Δa (at point of load)	$= \dfrac{Pa^2b^3}{12EIl^3}(3l + a)$
Δx (when $x < a$)	$= \dfrac{Pb^2x}{12EIl^3}(3al^2 - 2lx^2 - ax^2)$
Δx (when $x > a$)	$= \dfrac{Pa}{12EIl^3}(l-x)^2(3l^2x - a^2x - 2a^2l)$

BEAM DIAGRAMS AND FORMULAS
FOR VARIOUS STATIC LOADING CONDITIONS

**Equivalent Tabular Load is the uniformly distributed load given in the beam tables, pages 175 to 201.
For meaning of symbols, see page 6.**

15. BEAM FIXED AT BOTH ENDS—UNIFORMLY DISTRIBUTED LOADS



Equivalent Tabular Load . . . . . $= \dfrac{2wl}{3}$

R = V . . . . $= \dfrac{wl}{2}$

V_x . . . . $= w\left(\dfrac{l}{2} - x\right)$

M max. (at ends) . . . . $= \dfrac{wl^2}{12}$

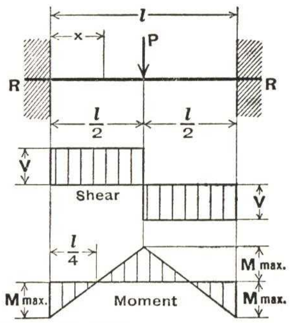
M_1 (at center) . . . . $= \dfrac{wl^2}{24}$

M_x . . . . $= \dfrac{w}{12}(6lx - l^2 - 6x^2)$

Δmax. (at center) . . . . $= \dfrac{wl^4}{384EI}$

Δx . . . . $= \dfrac{wx^2}{24EI}(l - x)^2$

16. BEAM FIXED AT BOTH ENDS—CONCENTRATED LOAD AT CENTER



Equivalent Tabular Load . . . . . $= P$

R = V . . . . $= \dfrac{P}{2}$

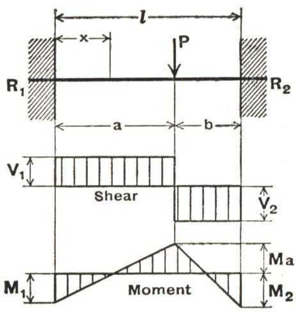
M max. (at center and ends) . . . $= \dfrac{Pl}{8}$

M_x (when $x < \dfrac{l}{2}$) . . . . . . $= \dfrac{P}{8}(4x - l)$

Δmax. (at center) . . . . $= \dfrac{Pl^3}{192EI}$

Δx . . . . $= \dfrac{Px^2}{48EI}(3l - 4x)$

17. BEAM FIXED AT BOTH ENDS—CONCENTRATED LOAD AT ANY POINT



$R_1 = V_1$ (max. when $a < b$) . . . $= \dfrac{Pb^2}{l^3}(3a + b)$

$R_2 = V_2$ (max. when $a > b$) . . . $= \dfrac{Pa^2}{l^3}(a + 3b)$

M_1 (max. when $a < b$) . . . $= \dfrac{Pab^2}{l^2}$

M_2 (max. when $a > b$) . . . $= \dfrac{Pa^2b}{l^2}$

M_a (at point of load) . . . $= \dfrac{2Pa^2b^2}{l^3}$

M_x (when $x < a$) . . . . . $= R_1x - \dfrac{Pab^2}{l^2}$

Δmax. (when $a > b$ at $x = \dfrac{2al}{3a + b}$) . $= \dfrac{2Pa^3b^2}{3EI\,(3a + b)^2}$

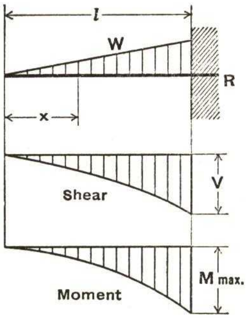
Δa (at point of load) . . . $= \dfrac{Pa^3b^3}{3EIl^3}$

Δx (when $x < a$) . . . . . . $= \dfrac{Pb^2x^2}{6EIl^3}(3al - 3ax - bx)$

BEAM DIAGRAMS AND FORMULAS
FOR VARIOUS STATIC LOADING CONDITIONS

Equivalent Tabular Load is the uniformly distributed load given in the beam tables, pages 175 to 201.
For meaning of symbols, see page 6.

18. CANTILEVER BEAM—LOAD INCREASING UNIFORMLY TO FIXED END



Equivalent Tabular Load . . . . $= \frac{8}{3} W$

R = V . . . . $= W$

V_x . . . . $= W \frac{x^2}{l^2}$

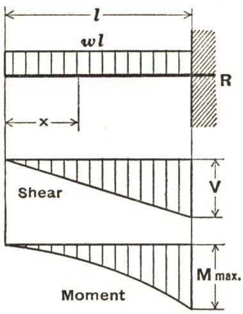
M max. (at fixed end) . . . . . $= \frac{Wl}{3}$

M_x . . . . $= \frac{Wx^3}{3l^2}$

Δmax. (at free end) . . . . . $= \frac{Wl^3}{15EI}$

Δx . . . . $= \frac{W}{60EIl^2}(x^5 - 5l^4x + 4l^5)$

19. CANTILEVER BEAM—UNIFORMLY DISTRIBUTED LOAD



Equivalent Tabular Load . . . . $= 4wl$

R = V . . . . $= wl$

V_x . . . . $= wx$

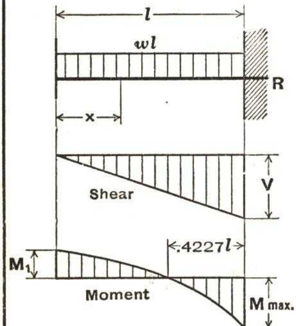
M max. (at fixed end) . . . . . $= \frac{wl^2}{2}$

M_x . . . . $= \frac{wx^2}{2}$

Δmax. (at free end) . . . . . $= \frac{wl^4}{8EI}$

Δx . . . . $= \frac{w}{24EI}(x^4 - 4l^3x + 3l^4)$

20. BEAM FIXED AT ONE END, FREE BUT GUIDED AT OTHER—UNIFORMLY DISTRIBUTED LOAD



The deflection at the guided end is assumed to be in a vertical plane.

Equivalent Tabular Load . . . . $= \frac{8}{3} wl$

R = V . . . . $= wl$

V_x . . . . $= wx$

M max. (at fixed end) . . . . . $= \frac{wl^2}{3}$

M_1 (at guided end) . . . . $= \frac{wl^2}{6}$

M_x . . . . $= \frac{w}{6}(l^2 - 3x^2)$

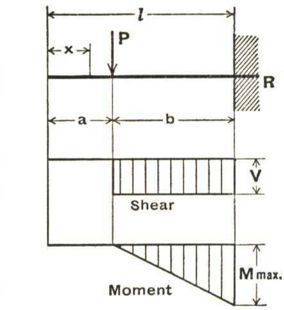
Δmax. (at guided end) . . . . $= \frac{wl^4}{24EI}$

Δx . . . . $= \frac{w(l^2 - x^2)^2}{24EI}$

BEAM DIAGRAMS AND FORMULAS
FOR VARIOUS STATIC LOADING CONDITIONS

Equivalent Tabular Load is the uniformly distributed load given in the beam tables, pages 175 to 201. For meaning of symbols, see page 6.

21. CANTILEVER BEAM—CONCENTRATED LOAD AT ANY POINT



Equivalent Tabular Load . . . . . $= \frac{8Pb}{l}$

$R = V$ (when $x < a$) . . . . $= P$

M max. (at fixed end) . . . . . . $= Pb$

M_x (when $x > a$) . . . . $= P(x - a)$

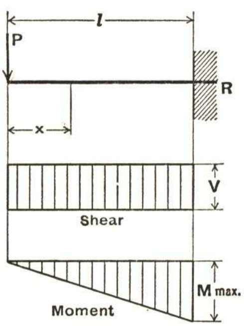
Δmax. (at free end) . . . . . . $= \frac{Pb^2}{6EI}(3l - b)$

Δa (at point of load) . . . . $= \frac{Pb^3}{3EI}$

Δx (when $x < a$) . . . . . . $= \frac{Pb^2}{6EI}(3l - 3x - b)$

Δx (when $x > a$) . . . . . . $= \frac{P(l - x)^2}{6EI}(3b - l + x)$

22. CANTILEVER BEAM—CONCENTRATED LOAD AT FREE END



Equivalent Tabular Load . . . . $= 8P$

$R = V$ . . . . $= P$

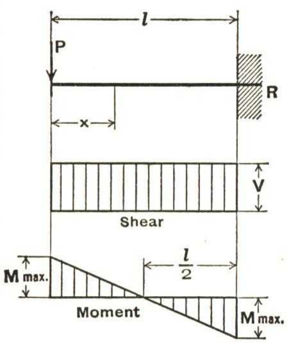
M max. (at fixed end) . . . . . . $= Pl$

M_x . . . . $= Px$

Δmax. (at free end) . . . . $= \frac{Pl^3}{3EI}$

Δx . . . . $= \frac{P}{6EI}(2l^3 - 3l^2x + x^3)$

23. BEAM FIXED AT ONE END, FREE BUT GUIDED AT OTHER—CONCENTRATED LOAD AT GUIDED END



The deflection at the guided end is assumed to be in a vertical plane.

Equivalent Tabular Load . . . . . $= 4P$

$R = V$ . . . . $= P$

M max. (at both ends) . . . . . $= \frac{Pl}{2}$

M_x . . . . $= P\left(\frac{l}{2} - x\right)$

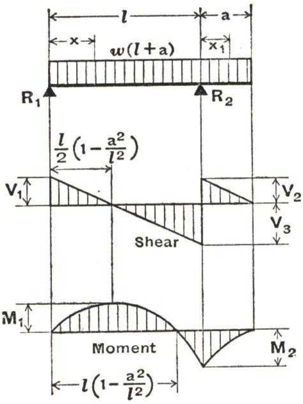
Δmax. (at guided end) . . . . . $= \frac{Pl^3}{12EI}$

Δx . . . . $= \frac{P(l - x)^2}{12EI}(l + 2x)$

BEAM DIAGRAMS AND FORMULAS
FOR VARIOUS STATIC LOADING CONDITIONS

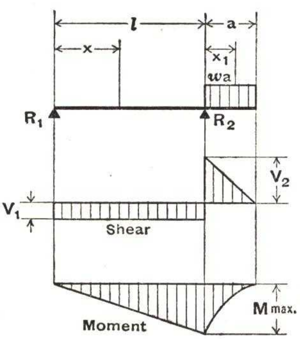
For meaning of symbols, see page 6.

24. BEAM OVERHANGING ONE SUPPORT—UNIFORMLY DISTRIBUTED LOAD



$R_1 = V_1$		$= \frac{w}{2l}(l^2 - a^2)$
$R_2 = V_2 + V_3$		$= \frac{w}{2l}(l + a)^2$
V_2		$= wa$
V_3		$= \frac{w}{2l}(l^2 + a^2)$
V_x	(between supports)	$= R_1 - wx$
V_{x_1}	(for overhang)	$= w(a - x_1)$
M_1	$\left(\text{at } x = \frac{l}{2}\left[1 - \frac{a^2}{l^2}\right]\right)$	$= \frac{w}{8l^2}(l + a)^2(l - a)^2$
M_2	(at R_2)	$= \frac{wa^2}{2}$
M_x	(between supports)	$= \frac{wx}{2l}(l^2 - a^2 - xl)$
M_{x_1}	(for overhang)	$= \frac{w}{2}(a - x_1)^2$
Δx	(between supports)	$= \frac{wx}{24EIl}(l^4 - 2l^2x^2 + lx^3 - 2a^2l^2 + 2a^2x^2)$
Δx_1	(for overhang)	$= \frac{wx_1}{24EI}(4a^2l - l^3 + 6a^2x_1 - 4ax_1^2 + x_1^3)$

25. BEAM OVERHANGING ONE SUPPORT—UNIFORMLY DISTRIBUTED LOAD ON OVERHANG

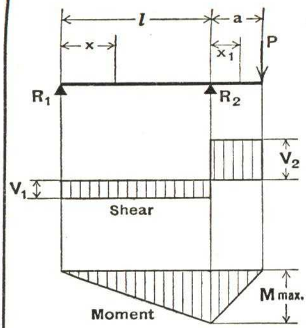


$R_1 = V_1$		$= \frac{wa^2}{2l}$
$R_2 = V_1 + V_2$		$= \frac{wa}{2l}(2l + a)$
V_2		$= wa$
V_{x_1}	(for overhang)	$= w(a - x_1)$
M max.	(at R_2)	$= \frac{wa^2}{2}$
M_x	(between supports)	$= \frac{wa^2x}{2l}$
M_{x_1}	(for overhang)	$= \frac{w}{2}(a - x_1)^2$
Δmax.	$\left(\text{between supports at } x = \frac{l}{\sqrt{3}}\right)$	$= \frac{wa^2l^2}{18\sqrt{3}EI} = .03208\,\frac{wa^2l^2}{EI}$
Δmax.	(for overhang at $x_1 = a$)	$= \frac{wa^3}{24EI}(4l + 3a)$
Δx	(between supports)	$= \frac{wa^2x}{12EIl}(l^2 - x^2)$
Δx_1	(for overhang)	$= \frac{wx_1}{24EI}(4a^2l + 6a^2x_1 - 4ax_1^2 + x_1^3)$

BEAM DIAGRAMS AND FORMULAS
FOR VARIOUS STATIC LOADING CONDITIONS

Equivalent Tabular Load is the uniformly distributed load given in the beam tables, pages 175 to 201.
For meaning of symbols, see page 6.

26. BEAM OVERHANGING ONE SUPPORT—CONCENTRATED LOAD AT END OF OVERHANG



$R_1 = V_1$ . . . . $= \dfrac{Pa}{l}$

$R_2 = V_1 + V_2$ . . . . $= \dfrac{P}{l}(l+a)$

V_2 . . . . $= P$

M max. (at R_2) . . . . $= Pa$

M_x (between supports) . . . $= \dfrac{Pax}{l}$

M_{x_1} (for overhang) . . . . $= P(a - x_1)$

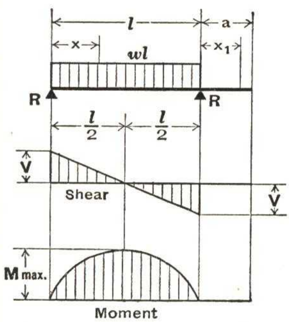
Δmax. (between supports at $x = \dfrac{l}{\sqrt{3}}$) $= \dfrac{Pal^2}{9\sqrt{3}EI} = .06415\dfrac{Pal^2}{EI}$

Δmax. (for overhang at $x_1 = a$) . $= \dfrac{Pa^2}{3EI}(l+a)$

Δx (between supports) . . $= \dfrac{Pax}{6EIl}(l^2 - x^2)$

Δx_1 (for overhang) . . . . $= \dfrac{Px_1}{6EI}(2al + 3ax_1 - x_1^2)$

27. BEAM OVERHANGING ONE SUPPORT—UNIFORMLY DISTRIBUTED LOAD BETWEEN SUPPORTS



Equivalent Tabular Load . . . $= wl$

$R = V$ . . . . $= \dfrac{wl}{2}$

V_x . . . . $= w\left(\dfrac{l}{2} - x\right)$

M max. (at center) . . . . . . $= \dfrac{wl^2}{8}$

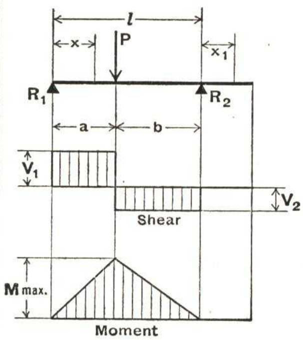
M_x . . . . $= \dfrac{wx}{2}(l - x)$

Δmax. (at center) . . . . . $= \dfrac{5wl^4}{384EI}$

Δx . . . . $= \dfrac{wx}{24EI}(l^3 - 2lx^2 + x^3)$

Δx_1 . . . . $= \dfrac{wl^3x_1}{24EI}$

28. BEAM OVERHANGING ONE SUPPORT—CONCENTRATED LOAD AT ANY POINT BETWEEN SUPPORTS



Equivalent Tabular Load . . . $= \dfrac{8Pab}{l^2}$

$R_1 = V_1$ (max. when $a < b$) . . . $= \dfrac{Pb}{l}$

$R_2 = V_2$ (max. when $a > b$) . . . $= \dfrac{Pa}{l}$

M max. (at point of load) . . . $= \dfrac{Pab}{l}$

M_x (when $x < a$) . . . . $= \dfrac{Pbx}{l}$

Δmax. (at $x = \sqrt{\dfrac{a(a+2b)}{3}}$ when $a > b$) $= \dfrac{Pab(a+2b)\sqrt{3a(a+2b)}}{27EIl}$

Δa (at point of load) . . . $= \dfrac{Pa^2b^2}{3EIl}$

Δx (when $x < a$) . . . . $= \dfrac{Pbx}{6EIl}(l^2 - b^2 - x^2)$

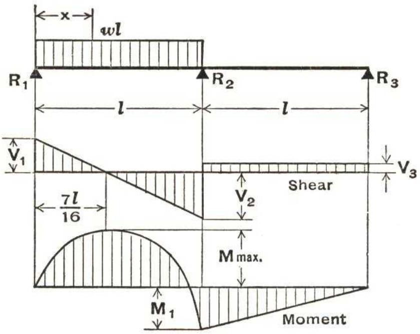
Δx (when $x > a$) . . . . $= \dfrac{Pa(l-x)}{6EIl}(2lx - x^2 - a^2)$

Δx_1 . . . . $= \dfrac{Pabx_1}{6EIl}(l+a)$

BEAM DIAGRAMS AND FORMULAS
FOR VARIOUS STATIC LOADING CONDITIONS

Equivalent Tabular Load is the uniformly distributed load given in the beam tables, pages 175 to 201. For meaning of symbols, see page 6.

29. CONTINUOUS BEAM—TWO EQUAL SPANS—UNIFORM LOAD ON ONE SPAN



Equivalent Tabular Load . . = $\frac{49}{64}wl$

$R_1=V_1$ . . . . = $\frac{7}{16}wl$

$R_2=V_2+V_3$ . . . . . = $\frac{5}{8}wl$

$R_3=V_3$ . . . . = $-\frac{1}{16}wl$

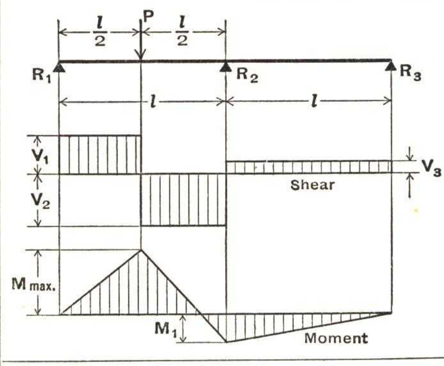
V_2 . . . . = $\frac{9}{16}wl$

M Max. $\left(\text{at } x=\frac{7}{16}l\right)$ . . = $\frac{49}{512}wl^2$

M_1 (at support R_2) . = $\frac{1}{16}wl^2$

M_x (when $x<l$) . . = $\frac{wx}{16}(7l-8x)$

30. CONTINUOUS BEAM—TWO EQUAL SPANS—CONCENTRATED LOAD AT CENTER OF ONE SPAN



Equivalent Tabular Load . = $\frac{13}{8}P$

$R_1=V_1$ . . . . = $\frac{13}{32}P$

$R_2=V_2+V_3$ . . . . . = $\frac{11}{16}P$

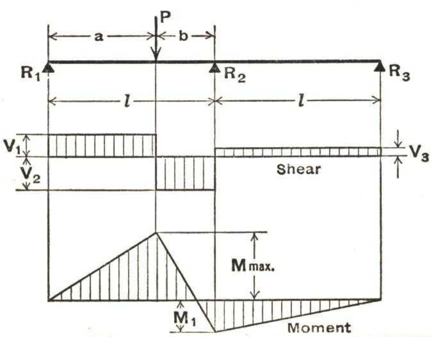
$R_3=V_3$ . . . . = $-\frac{3}{32}P$

V_2 . . . . = $\frac{19}{32}P$

M Max. (at point of load) . = $\frac{13}{64}Pl$

M_1 (at support R_2) . = $\frac{3}{32}Pl$

31. CONTINUOUS BEAM—TWO EQUAL SPANS—CONCENTRATED LOAD AT ANY POINT



$R_1=V_1$ . . . . = $\frac{Pb}{4l^3}\left(4l^2-a(l+a)\right)$

$R_2=V_2+V_3$ . . . . . = $\frac{Pa}{2l^3}\left(2l^2+b(l+a)\right)$

$R_3=V_3$ . . . . = $-\frac{Pab}{4l^3}(l+a)$

V_2 . . . . = $\frac{Pa}{4l^3}\left(4l^2+b(l+a)\right)$

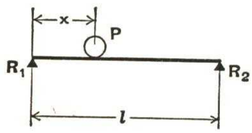
M max. (at point of load) . = $\frac{Pab}{4l^3}\left(4l^2-a(l+a)\right)$

M_1 (at support R_2) . = $\frac{Pab}{4l^2}(l+a)$

BEAM DIAGRAMS AND FORMULAS
FOR VARIOUS CONCENTRATED MOVING LOADS

The values given in these formulas do not include impact which varies according to the requirements of each case.
For meaning of symbols, see page 6.

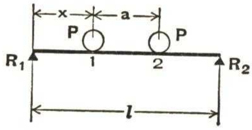
32. SIMPLE BEAM—ONE CONCENTRATED MOVING LOAD



R_1 max. = V_1 max. $\left(\text{at } x = o\right)$ . . . . . $= P$

M max. $\left(\text{at point of load, when } x = \frac{l}{2}\right)$. $= \frac{Pl}{4}$

33. SIMPLE BEAM—TWO EQUAL CONCENTRATED MOVING LOADS

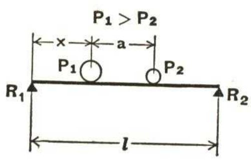


R_1 max. = V_1 max. $\left(\text{at } x = o\right)$ . . . . . $= P\left(2 - \frac{a}{l}\right)$

M max.

- when $a < (2 - \sqrt{2})\, l = .586l$ under load 1 at $x = \frac{1}{2}\left(l - \frac{a}{2}\right)$ $= \frac{P}{2l}\left(l - \frac{a}{2}\right)^2$
- when $a > (2 - \sqrt{2})\, l = .586l$ with one load at center of span (case 32) $= \frac{Pl}{4}$

34. SIMPLE BEAM—TWO UNEQUAL CONCENTRATED MOVING LOADS

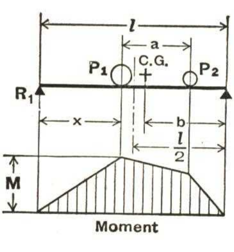


R_1 max. = V_1 max. $\left(\text{at } x = o\right)$ . . . . . $= P_1 + P_2 \frac{l - a}{l}$

M max.

- $\left[\text{under } P_1, \text{ at } x = \frac{1}{2}\left(l - \frac{P_2 a}{P_1 + P_2}\right)\right] = \left(P_1 + P_2\right)\frac{x^2}{l}$
- M max. may occur with larger load at center of span and other load off span (case 32) $= \frac{P_1 l}{4}$

GENERAL RULES FOR SIMPLE BEAMS CARRYING MOVING CONCENTRATED LOADS



The maximum shear due to moving concentrated loads occurs at one support when one of the loads is at that support. With several moving loads, the location that will produce maximum shear must be determined by trial.

The maximum bending moment produced by moving concentrated loads occurs under one of the loads when that load is as far from one support as the center of gravity of all the moving loads on the beam is from the other support.

In the accompanying diagram, the maximum bending moment occurs under load P_1 when $x = b$. It should also be noted that this condition occurs when the center line of the span is midway between the center of gravity of loads and the nearest concentrated load.

CONTINUOUS SPAN COEFFICIENTS

Continuous spans are frequently used to reduce the maximum moments, in both bridge and building construction; for beams and girders framing to columns in tier buildings they are seldom economical, despite the saving in main material, on account of the added cost of necessary details at the supports.

The methods of calculation of shears and moments in continuous beams proceed from the fundamental "Theorem of Three Moments" stated in convenient form on page 365.

The design of continuous spans can be safely entrusted only to designers with an adequate grasp of the underlying theory and of the behavior of such structures; to these, however, it is an advantage to have available such short cuts as may lighten the tedious arithmetical work.

To this end there are here presented four tables of coefficients, two for two-span and two for three-span continuous beams. In the former, the shorter span bears a variety of ratios to the total length. In the latter, the two end spans are equal, and again the length of each bears a variety of ratios to the total length.

The following general considerations apply to the use of all these tables:

(1) The span-ratios chosen are intended to embrace those that frequently occur in practice. The intervals between span-ratios tabulated are close enough so that straight-line interpolation for other ratios ("vertical interpolation") will not introduce too great errors.

(2) Theoretically, the tabulated coefficients for a particular function under investigation are to be used as ordinates to a series of points, through which the "influence line" for the function is to be drawn in as a smooth curve. The number of such ordinates provided, enables such a curve to be faired in with sufficient accuracy for most purposes.

(3) The actual drawing of influence lines can in many cases be avoided by a reasoned use of the tabulated information. For instance: for many short spans the maximum negative and maximum positive moment, directly obtainable from coefficients in the tables, will suffice to determine the size of the required beam.

(4) Both spans in two-span beams, and both end spans of three-span beams, are divided into fifths because the maximum positive moments from single loads occur very close to the two-fifths points from the end supports. The central span of three-span beams is divided into fourths because this maximum occurs at mid-span.

(5) The spacing of a specified group of concentrated loads is apt to be such that with one load placed at one of the fifth or quarter points tabulated, other loads fall between such points. Exact coefficients for such loads do not result from straight-line interpolation ("horizontal interpolation") between the tabulated coefficients to right and to left, because the influence line between those points is a curve. Only in regions of sharp curvature, however, is the error important; and a mental correction to the straight-line interpolation, taking into account the direction of curvature of the influence line, is feasible.

(6) All shear and moment coefficients have been expressed in terms of "L", the total length of the two (or three) spans. This is done in order that if, as is frequently the case, the total length is fixed and the intermediate span lengths are subject to the designer's discretion, comparison of the various functions for various layouts may be made on a common and constant basis.

CONTINUOUS SPAN COEFFICIENTS

TWO-SPAN TABLES

The first of the two-span tables gives the three reactions due to a unit load placed successively at each of eleven points (the three support points plus the fifth points in each span). From these reactions, all shears and moments due to a single load in any one of the eleven positions can be quickly calculated.

For moving groups of two or more loads it will usually be desirable to plot the influence lines for all the shears and moments required in the design. The influence line ordinates for the maximum negative moment are tabulated (M_5). Maximum positive moment will occur at an undetermined point, but this point will lie not far from the point where a single load produces maximum moment; the position of this point is tabulated (see +M (max.)). Influence lines may be drawn, from the reaction tables, for this point and for other points close by, and these will envelop the influence line for absolute maximum positive moment in the span.

For longer spans, where changes of section will need to be made, the influence ordinates for moment (and sometimes for shear) may be calculated (from the reaction tables) at each of the fifth points. From these the maximum moment at each fifth point may be found and plotted to scale, and a moment curve faired through the eleven points thus established. This will provide the information for a detailed design for bending stress.

The second of the two-span tables simplifies the calculation of shears and moments in the case of uniform load per lineal foot. Coefficients for shears at each of the three support points are tabulated. If any further shears are required they can best be obtained from shear influence lines.

For uniform loading, the maximum moment of each sign, at any point, occurs with one span completely loaded and the other span empty; except at and close to the interior support, where all loads on either span cause negative moment. Moment coefficients are accordingly given for each separate span loaded (M1 and M2) and from these the maximum moments of each sign (Max. M and Rev. M) are directly set down.

THREE-SPAN TABLES

The first of the three-span tables gives the four reactions due to a unit load placed successively at each of fifteen points. Since the end spans are equal, two of these reactions are in reverse to the other two. The remaining notes, above, on the first of the two-span tables, apply to this table as well.

The second of the three-span tables simplifies the calculation of the shears and moments usually required in the case of uniform load per lineal foot.

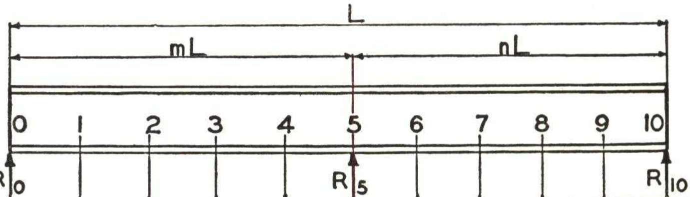
Load covering one end span (M_1) produces positive moment throughout that span (except quite close to the intermediate support) and in the other end span to and including its intermediate support; and produces negative moment throughout the center span (except quite close to the far intermediate support). Load covering the center span (M_2) produces positive moment throughout that span (except quite close to the intermediate supports) and produces negative moment throughout both end spans to and including the intermediate supports.

Therefore load covering all three spans (M_3) does not produce the maximum moment at any point, but the coefficients as tabulated will often be required for the case of dead load.

For uniform live loading, the numerically greatest moment will occur at some points with one span, at some with two adjacent spans, and at some with two end spans, loaded. The coefficients for these moments are tabulated as Max. M. Inspection will show what combinations of M_1, M_2 and M_1 reversed, produce them. The same is true of Rev. M, the greatest moment of opposite sign to Max. M.

TWO-SPAN CONTINUOUS BEAMS

CONSTANT MOMENT OF INERTIA — CONCENTRATED LOAD UNITY



		m	n	R_0 (0)	1	2	3	4	R_5 (5)	6	7	8	9	R_{10} (10)
COEFFICIENTS × UNIT LOAD P	R_0	.30	.70	1.0	.771	.550	.342	.157	0	–.235	–.314	–.274	–.157	0
		.35	.65	1.0	.766	.541	.333	.150	0	–.174	–.232	–.203	–.116	0
		.40	.60	1.0	.762	.533	.323	.142	0	–.130	–.173	–.151	–.086	0
		.45	.55	1.0	.757	.524	.314	.135	0	–.097	–.129	–.113	–.065	0
		.50	.50	1.0	.752	.516	.304	.128	0	–.072	–.096	–.084	–.048	0
	R_5	.30	.70	0	.241	.472	.682	.862	1.0	1.136	1.048	.792	.425	0
		.35	.65	0	.252	.491	.703	.878	1.0	1.067	.957	.712	.378	0
		.40	.60	0	.264	.512	.728	.896	1.0	1.016	.888	.652	.344	0
		.45	.55	0	.279	.538	.757	.918	1.0	.976	.835	.605	.317	0
		.50	.50	0	.296	.568	.792	.944	1.0	.944	.792	.568	.296	0
	R_{10}	.30	.70	0	–.012	–.022	–.025	–.019	0	.099	.266	.482	.733	1.0
		.35	.65	0	–.018	–.032	–.036	–.027	0	.106	.275	.491	.738	1.0
		.40	.60	0	–.025	–.045	–.051	–.038	0	.114	.285	.499	.742	1.0
		.45	.55	0	–.035	–.062	–.071	–.053	0	.121	.294	.508	.747	1.0
		.50	.50	0	–.048	–.084	–.096	–.072	0	.128	.304	.516	.752	1.0
COEFFICIENTS × P L	M_5	.30	.70	0	–.009	–.015	–.017	–.013	0	–.071	–.094	–.082	–.047	0
		.35	.65	0	–.012	–.021	–.024	–.018	0	–.061	–.081	–.071	–.041	0
		.40	.60	0	–.015	–.027	–.031	–.023	0	–.052	–.069	–.061	–.035	0
		.45	.55	0	–.019	–.034	–.039	–.029	0	–.044	–.058	–.051	–.029	0
		.50	.50	0	–.024	–.042	–.048	–.036	0	–.036	–.048	–.042	–.024	0

		m	n	+ M(max) (span mL)	+ M(max) (span nL)
COEFFICIENTS × P L	+M (max.)	.30	.70	.067 at x = .460 (.30) L	.135 at x = .405 (.70) L
		.35	.65	.077 at x = .454 (.35) L	.128 at x = .412 (.65) L
		.40	.60	.086 at x = .446 (.40) L	.120 at x = .419 (.60) L
		.45	.55	.095 at x = .439 (.45) L	.112 at x = .426 (.55) L
		.50	.50	.104 at x = .432 (.50) L	.104 at x = .432 (.50) L

R_0, R_5 and R_{10} are the reactions, at supports 0, 5, 10 respectively, for a concentrated load of unity applied at the point indicated at the head of each column of coefficients.

From these reactions it is possible to construct the influence lines for maximum shear or maximum moment at any section.

M_5 is the moment (always negative) at the intermediate support 5, due to unit load placed at the point indicated. These moments constitute the ordinates to the influence line for moment at 5. The total negative moment due to two or more concentrated loads is the sum of the negative moments due to each.

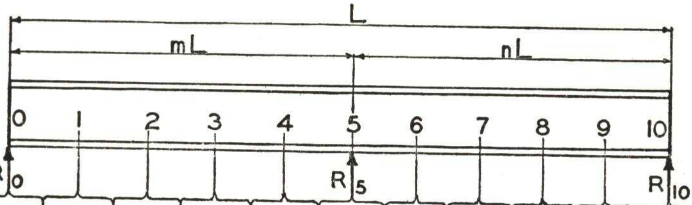
+M (max.) defines the load position for maximum positive moment, and gives the moment coefficient, in each span respectively. This information accurately locates the peak of the influence line for maximum positive moment due to a single load.

Coefficients for span ratios m, n, not given, may be approximated by direct interpolation between the two nearest values tabulated.

TWO-SPAN CONTINUOUS BEAMS

CONSTANT MOMENT OF INERTIA

UNIFORM LOAD w PER UNIT OF LENGTH, COMPLETELY COVERING ONE OR BOTH SPANS.



COEFFICIENTS $\times wL$

	m	n	R_0		R_5	R_{10}
Max. Shear	.30	.70	.139	−.304	.416 (.720 = Max. R_5)	−.289
	.35	.65	.160	−.288	.386 (.674	−.272
	.40	.60	.180	−.288	.358 (.646	−.255
	.45	.55	.200	−.296	.334 (.630	−.237
	.50	.50	.219	−.3125	.3125 (.625	−.219

COEFFICIENTS $\times wL^2$

	m	n	0	1	2	3	4	5	6	7	8	9	10
M_1	.30	.70	0	.007	.010	.009	.005	−.003	−.003	−.002	−.001	−.001	0
	.35	.65	0	.009	.013	.012	.006	−.005	−.004	−.003	−.002	−.001	0
	.40	.60	0	.011	.016	.014	.006	−.008	−.006	−.005	−.003	−.002	0
	.45	.55	0	.014	.020	.018	.007	−.011	−.009	−.007	−.005	−.002	0
	.50	.50	0	.017	.024	.021	.008	−.016	−.013	−.009	−.006	−.003	0
M_2	.30	.70	0	−.009	−.017	−.026	−.034	−.043	.005	.033	.042	.031	0
	.35	.65	0	−.007	−.014	−.021	−.028	−.034	.006	.030	.037	.027	0
	.40	.60	0	−.005	−.011	−.016	−.022	−.027	.007	.027	.032	.023	0
	.45	.55	0	−.004	−.008	−.013	−.017	−.021	.008	.024	.028	.020	0
	.50	.50	0	−.003	−.006	−.009	−.013	−.016	.008	.021	.024	.017	0
Max. M	.30	.70	0	−.009	−.017	−.026	−.034	−.046	.005	.033	.042	.031	0
	.35	.65	0	.009	−.014	−.021	−.028	−.040	.006	.030	.037	.027	0
	.40	.60	0	.011	.016	−.016	−.022	−.035	.007	.027	.032	.023	0
	.45	.55	0	.014	.020	.018	−.017	−.032	−.009	.024	.028	.020	0
	.50	.50	0	.017	.024	.021	−.013	−.031	−.013	.021	.024	.017	0
Rev. M	.30	.70	0	.007	.010	.009	.005		−.003	−.002	−.001	−.001	0
	.35	.65	0	−.007	.013	.012	.006		−.004	−.003	−.002	−.001	0
	.40	.60	0	−.005	−.011	.014	.006		−.006	−.005	−.003	−.002	0
	.45	.55	0	−.004	−.008	−.013	.007		.008	−.007	−.005	−.002	0
	.50	.50	0	−.003	−.006	−.009	.008		.008	−.009	−.006	−.003	0

Max. Shear ($\times wL$) is the maximum shear on the indicated side of the support, due to uniform load of w per lin. ft. in the most effective position for shear.

M_1 and M_2 ($\times wL^2$) are the moments at the indicated points due to uniform load w covering, respectively, the left and the right span.

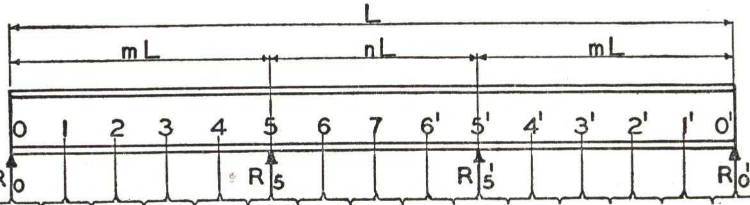
Max. M = maximum possible moment of either sign at the indicated point due to uniform load, and results from covering one complete span; except at and near the center support, where it results from covering both spans. The maximum possible positive moment occurs close to, and is negligibly greater than, that shown at Points 2 and 8.

Rev. M = maximum moment of reverse sign to Max. M.

THREE-SPAN SYMMETRICAL CONTINUOUS BEAMS

CONSTANT MOMENT OF INERTIA

CONCENTRATED LOAD UNITY

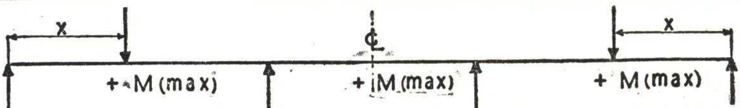


COEFFICIENTS × UNIT LOAD P

	m	n	0	1	2	3	4	5	6	7	6'	5'	4'	3'	2'	1'	0'
R_0	.25	.50	1.0	.764	.537	.328	.146	0	-.188	-.188	-.094	0	.018	.024	.021	.012	0
	.30	.40	1.0	.755	.522	.310	.133	0	-.108	-.111	-.058	0	.019	.026	.022	.013	0
	⅓	⅓	1.0	.749	.510	.298	.123	0	-.072	-.075	-.041	0	.019	.026	.022	.013	0
	⅜	¼	1.0	.740	.495	.280	.110	0	-.039	-.042	-.023	0	.018	.024	.021	.012	0
	.40	.20	1.0	.734	.485	.268	.101	0	-.025	-.027	-.015	0	.017	.022	.019	.011	0
R_5	.25	.50	0	.260	.505	.720	.890	1.0	.984	.688	.297	0	-.054	-.072	-.063	-.036	0
	.30	.40	0	.288	.554	.776	.932	1.0	.896	.611	.271	0	-.084	-.112	-.098	-.056	0
	⅓	⅓	0	.315	.602	.830	.973	1.0	.853	.575	.259	0	-.115	-.154	-.134	-.077	0
	⅜	¼	0	.368	.694	.936	**1.052**	1.0	.812	.542	.250	0	-.180	-.240	-.210	-.120	0
	.40	.20	0	.419	.784	**1.039**	**1.129**	1.0	.794	.527	.247	0	-.247	-.329	-.288	-.165	0
R_5'			Reverse the tabulated coefficients for R_5, from left to right.														
R_0'			Reverse the tabulated coefficients for R_0, from left to right.														

COEFFICIENTS × P L

	m	n	0	1	2	3	4	5	6	7	6'	5'	4'	3'	2'	1'	0'
M_5	.25	.50	0	-.009	-.016	-.018	-.014	0	-.047	-.047	-.024	0	.005	.006	.005	.003	0
	.30	.40	0	-.013	-.024	-.027	-.020	0	-.032	-.033	-.017	0	.006	.008	.007	.004	0
	⅓	⅓	0	-.017	-.030	-.034	-.026	0	-.024	-.025	-.014	0	.006	.009	.008	.004	0
	⅜	¼	0	-.023	-.039	-.045	-.034	0	-.015	-.016	-.009	0	.007	.009	.008	.005	0
	.40	.20	0	-.026	-.046	-.053	-.040	0	-.010	-.011	-.006	0	.007	.009	.008	.004	0
M_5'			Reverse the tabulated coefficients for M_5, from left to right.														



	m	n	+ M (max)	+ M (max)	+ M (max)
+M (max.)	.25	.50	.054 at x = .449 (.25) L	.078	.054 at x = .449 (.25) L
	.30	.40	.063 at x = .437 (.30) L	.067	.063 at x = .437 (.30) L
	⅓	⅓	.068 at x = .428 (⅓) L	.058	.068 at x = .428 (⅓) L
	⅜	¼	.074 at x = .415 (⅜) L	.047	.074 at x = .415 (⅜) L
	.40	.20	.078 at x = .407 (.40) L	.039	.078 at x = .407 (.40) L

R_0, R_5, R_5' and R_0' are the reactions, at supports 0, 5, 5′, and 0′ respectively, for a concentrated load of unity applied at the point indicated at the head of each column of coefficients.

From these reactions it is possible to construct the influence lines for maximum shear or maximum moment at any section.

M_5 is the moment at the intermediate support R_5, due to unit load placed at the point indicated. It is negative except when the load is placed on the farther end span. The tabulated moment coefficients constitute ordinates to the influence line for moment at 5. For M_5' they are reversed from left to right. Maximum moment at either interior support will occur with the farther end span unloaded. The total moment at 5 or 5′, due to two or more concentrated loads, is the algebraic sum of the coefficients tabulated above for the points at which the several loads are placed. Usually it is greatest when they are placed in the longer of the two spans adjacent to the support.

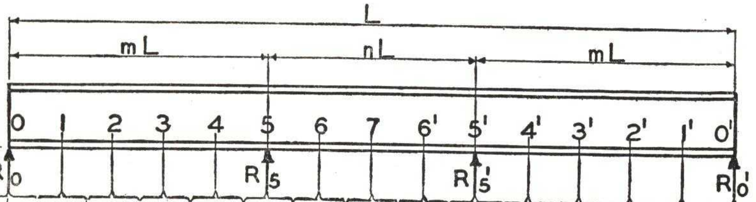
+M (max.) defines the load position for maximum positive moment, and gives the moment coefficient, in each span respectively. This information accurately locates the peak of the influence line for maximum positive moment due to a single load.

Coefficients for span-ratios m, n, not given, may be approximated by direct interpolation between the two nearest values tabulated.

THREE-SPAN SYMMETRICAL CONTINUOUS BEAMS

CONSTANT MOMENT OF INERTIA

UNIFORM LOAD *w* PER UNIT OF LENGTH



COEF. × w L

	m	n	R_0	R_5 (left)	R_5 (right)
Max. Shear	.25	.50	.1172	–.1992	.2578 (.4570 Max. R_5
	.30	.40	.1375	–.1971	.2169 (.4140
	⅓	⅓	.1500	–.2056	.1944 (.4000
	⅜	¼	.1641	–.2237	.1777 (.4014
	.40	.20	.1714	–.2379	.1800 (.4179

NOTE! Prefix .0 to all tabulated Moments; thus, 044 signifies .0044

COEFFICIENTS × 0.0 w L²

	m	n	0	1	2	3	4	5	6	7	6'	5'	4'	3'	2'	1'	0'
M_1	.25	.50	0	044	063	057	027	–029	–020	–010	0	010	008	006	004	002	0
	.30	.40	0	062	087	077	030	–053	–036	–019	–002	015	012	009	006	003	0
	⅓	⅓	0	074	104	089	030	–074	–051	–028	–005	019	015	011	007	004	0
	⅜	¼	0	091	125	103	025	–110	–077	–044	–011	022	018	013	009	004	0
	.40	.20	0	101	137	110	018	–137	–097	–057	–017	023	018	014	009	005	0
M_2	.25	.50	0	–031	–063	–094	–125	–156	078	156	078	–156	–125	–094	–063	–031	0
	.30	.40	0	–018	–036	–053	–071	–089	061	111	061	–089	–071	–053	–036	–018	0
	⅓	⅓	0	–011	–022	–033	–044	–056	049	083	049	–056	–044	–033	–022	–011	0
	⅜	¼	0	–005	–010	–016	–021	–026	033	052	033	–026	–021	–016	–010	–005	0
	.40	.20	0	–003	–006	–009	–011	–014	023	036	023	–014	–011	–009	–006	–003	0
M_3	.25	.50	0	015	005	–030	–091	–176	059	137	059	–176	–091	–030	005	015	0
	.30	.40	0	047	057	032	–029	–126	024	074	024	–126	–029	032	057	047	0
	⅓	⅓	0	067	089	067	000	–111	–007	028	–007	–111	000	067	089	067	0
	⅜	¼	0	090	123	100	021	–114	–055	–036	–055	–114	021	100	123	090	0
	.40	.20	0	102	141	115	025	–129	–091	–079	–091	–129	025	115	141	102	0
Max. M	.25	.50	0	046	067	–094	–125	–186	078	156	078	–186	–125	–094	067	046	0
	.30	.40	0	065	093	086	–071	–141	061	111	061	–141	–071	086	093	065	0
	⅓	⅓	0	078	111	100	044	–130	–056	083	–056	–130	044	100	111	078	0
	⅜	¼	0	095	134	116	042	–136	–088	–088	–088	–136	042	116	134	095	0
	.40	.20	0	105	146	123	037	–151	–114	–114	–114	–151	037	123	146	105	0
Rev. M	.25	.50	0	–031	–063	063	034	010	–020	–020	–020	010	034	063	–063	–031	0
	.30	.40	0	–018	–036	–053	042	015	–038	–038	–038	015	042	–053	–036	–018	0
	⅓	⅓	0	–011	–022	–033	–044	019	049	–056	049	019	–044	–033	–022	–011	0
	⅜	¼	0	–005	–010	–016	–021	022	033	052	033	022	–021	–016	–010	–005	0
	.40	.20	0	–003	–006	–009	–011	023	023	036	023	023	–011	–009	–006	–003	0

Max. shear (x w L) is the maximum shear on the indicated side of the support, due to uniform load of w per lin. ft. in the most effective position for shear.

M_1 and M_2 (x w L²) are the moments at the indicated points due to uniform load w covering, respectively, the left and the center span. (Moments from load covering the right hand span are the reverse from left to right, of M_1 and are not tabulated.)

M_3 = moment at the indicated point due to load covering all spans; which is not a condition for maximum.

Max. M = maximum possible moment of either sign at the indicated point, and is due to uniform load covering one complete span or two complete spans. In the end spans the maximum possible positive moment occurs close to, and is negligibly greater than, that shown at Points 2 and 2′.

Rev. M = maximum moment of reverse sign to Max. M.

CAMBER

Given the length and depth of beam, girder or truss, and the design unit stress: then the corresponding factor from the table below, multiplied by the length in feet, will give the center deflection in inches.

For unit stress values not tabulated, multiply the factor for 10 000 p. s. i. by the ratio of the design unit stress to 10 000.

This Table assumes uniformly distributed loading. For a single load at center multiply these factors by 0.8; for two equal loads at the third points, by 1.02.

Ratio of $\frac{\text{Depth}}{\text{Span}}$	Maximum Fibre Stress in Lbs. per Sq. In.					
	10 000	12 000	14 000	16 000	18 000	20 000
1/4	.0034	.0041	.0048	.0054	.0061	.0068
1/5	.0043	.0051	.0060	.0068	.0077	.0085
1/6	.0051	.0061	.0072	.0082	.0092	.0102
1/7	.0060	.0072	.0084	.0096	.0107	.0119
1/8	.0068	.0082	.0095	.0109	.0123	.0136
1/9	.0077	.0092	.0107	.0123	.0138	.0153
1/10	.0085	.0102	.0119	.0136	.0153	.0170
1/11	.0094	.0112	.0131	.0150	.0169	.0187
1/12	.0102	.0122	.0143	.0164	.0184	.0204

Factors are strictly correct for beams of constant section; close for cover-plated beams and girders, and reasonably approximate for trusses. Simple spans are contemplated herein.

NATURAL SINES

Angle	0′	10′	20′	30′	40′	50′	60′	
0°	0.00000	0.00291	0.00582	0.00873	0.01164	0.01454	0.01745	89°
1	0.01745	0.02036	0.02327	0.02618	0.02908	0.03199	0.03490	88
2	0.03490	0.03781	0.04071	0.04362	0.04653	0.04943	0.05234	87
3	0.05234	0.05524	0.05814	0.06105	0.06395	0.06685	0.06976	86
4	0.06976	0.07266	0.07556	0.07846	0.08136	0.08426	0.08716	85
5	0.08716	0.09005	0.09295	0.09585	0.09874	0.10164	0.10453	84
6	0.10453	0.10742	0.11031	0.11320	0.11609	0.11898	0.12187	83
7	0.12187	0.12476	0.12764	0.13053	0.13341	0.13629	0.13917	82
8	0.13917	0.14205	0.14493	0.14781	0.15069	0.15356	0.15643	81
9	0.15643	0.15931	0.16218	0.16505	0.16792	0.17078	0.17365	80
10	0.17365	0.17651	0.17937	0.18224	0.18509	0.18795	0.19081	79
11	0.19081	0.19366	0.19652	0.19937	0.20222	0.20507	0.20791	78
12	0.20791	0.21076	0.21360	0.21644	0.21928	0.22212	0.22495	77
13	0.22495	0.22778	0.23062	0.23345	0.23627	0.23910	0.24192	76
14	0.24192	0.24474	0.24756	0.25038	0.25320	0.25601	0.25882	75
15	0.25882	0.26163	0.26443	0.26724	0.27004	0.27284	0.27564	74
16	0.27564	0.27843	0.28123	0.28402	0.28680	0.28959	0.29237	73
17	0.29237	0.29515	0.29793	0.30071	0.30348	0.30625	0.30902	72
18	0.30902	0.31178	0.31454	0.31730	0.32006	0.32282	0.32557	71
19	0.32557	0.32832	0.33106	0.33381	0.33655	0.33929	0.34202	70
20	0.34202	0.34475	0.34748	0.35021	0.35293	0.35565	0.35837	69
21	0.35837	0.36108	0.36379	0.36650	0.36921	0.37191	0.37461	68
22	0.37461	0.37730	0.37999	0.38268	0.38537	0.38805	0.39073	67
23	0.39073	0.39341	0.39608	0.39875	0.40141	0.40408	0.40674	66
24	0.40674	0.40939	0.41204	0.41469	0.41734	0.41998	0.42262	65
25	0.42262	0.42525	0.42788	0.43051	0.43313	0.43575	0.43837	64
26	0.43837	0.44098	0.44359	0.44620	0.44880	0.45140	0.45399	63
27	0.45399	0.45658	0.45917	0.46175	0.46433	0.46690	0.46947	62
28	0.46947	0.47204	0.47460	0.47716	0.47971	0.48226	0.48481	61
29	0.48481	0.48735	0.48989	0.49242	0.49495	0.49748	0.50000	60
30	0.50000	0.50252	0.50503	0.50754	0.51004	0.51254	0.51504	59
31	0.51504	0.51753	0.52002	0.52250	0.52498	0.52745	0.52992	58
32	0.52992	0.53238	0.53484	0.53730	0.53975	0.54220	0.54464	57
33	0.54464	0.54708	0.54951	0.55194	0.55436	0.55678	0.55919	56
34	0.55919	0.56160	0.56401	0.56641	0.56880	0.57119	0.57358	55
35	0.57358	0.57596	0.57833	0.58070	0.58307	0.58543	0.58779	54
36	0.58779	0.59014	0.59248	0.59482	0.59716	0.59949	0.60182	53
37	0.60182	0.60414	0.60645	0.60876	0.61107	0.61337	0.61566	52
38	0.61566	0.61795	0.62024	0.62251	0.62479	0.62706	0.62932	51
39	0.62932	0.63158	0.63383	0.63608	0.63832	0.64056	0.64279	50
40	0.64279	0.64501	0.64723	0.64945	0.65166	0.65386	0.65606	49
41	0.65606	0.65825	0.66044	0.66262	0.66480	0.66697	0.66913	48
42	0.66913	0.67129	0.67344	0.67559	0.67773	0.67987	0.68200	47
43	0.68200	0.68412	0.68624	0.68835	0.69046	0.69256	0.69466	46
44°	0.69466	0.69675	0.69883	0.70091	0.70298	0.70505	0.70711	45°
	60′	50′	40′	30′	20′	10′	0′	Angle

NATURAL COSINES

NATURAL SINES

Angle	0′	10′	20′	30′	40′	50′	60′	
45°	0.70711	0.70916	0.71121	0.71325	0.71529	0.71732	0.71934	44°
46	0.71934	0.72136	0.72337	0.72537	0.72737	0.72937	0.73135	43
47	0.73135	0.73333	0.73531	0.73728	0.73924	0.74120	0.74314	42
48	0.74314	0.74509	0.74703	0.74896	0.75088	0.75280	0.75471	41
49	0.75471	0.75661	0.75851	0.76041	0.76229	0.76417	0.76604	40
50	0.76604	0.76791	0.76977	0.77162	0.77347	0.77531	0.77715	39
51	0.77715	0.77897	0.78079	0.78261	0.78442	0.78622	0.78801	38
52	0.78801	0.78980	0.79158	0.79335	0.79512	0.79688	0.79864	37
53	0.79864	0.80038	0.80212	0.80386	0.80558	0.80730	0.80902	36
54	0.80902	0.81072	0.81242	0.81412	0.81580	0.81748	0.81915	35
55	0.81915	0.82082	0.82248	0.82413	0.82577	0.82741	0.82904	34
56	0.82904	0.83066	0.83228	0.83389	0.83549	0.83708	0.83867	33
57	0.83867	0.84025	0.84182	0.84339	0.84495	0.84650	0.84805	32
58	0.84805	0.84959	0.85112	0.85264	0.85416	0.85567	0.85717	31
59	0.85717	0.85866	0.86015	0.86163	0.86310	0.86457	0.86603	30
60	0.86603	0.86748	0.86892	0.87036	0.87178	0.87321	0.87462	29
61	0.87462	0.87603	0.87743	0.87882	0.88020	0.88158	0.88295	28
62	0.88295	0.88431	0.88566	0.88701	0.88835	0.88968	0.89101	27
63	0.89101	0.89232	0.89363	0.89493	0.89623	0.89752	0.89879	26
64	0.89879	0.90007	0.90133	0.90259	0.90383	0.90507	0.90631	25
65	0.90631	0.90753	0.90875	0.90996	0.91116	0.91236	0.91355	24
66	0.91355	0.91472	0.91590	0.91706	0.91822	0.91936	0.92050	23
67	0.92050	0.92164	0.92276	0.92388	0.92499	0.92609	0.92718	22
68	0.92718	0.92827	0.92935	0.93042	0.93148	0.93253	0.93358	21
69	0.93358	0.93462	0.93565	0.93667	0.93769	0.93869	0.93969	20
70	0.93969	0.94068	0.94167	0.94264	0.94361	0.94457	0.94552	19
71	0.94552	0.94646	0.94740	0.94832	0.94924	0.95015	0.95106	18
72	0.95106	0.95195	0.95284	0.95372	0.95459	0.95545	0.95630	17
73	0.95630	0.95715	0.95799	0.95882	0.95964	0.96046	0.96126	16
74	0.96126	0.96206	0.96285	0.96363	0.96440	0.96517	0.96593	15
75	0.96593	0.96667	0.96742	0.96815	0.96887	0.96959	0.97030	14
76	0.97030	0.97100	0.97169	0.97237	0.97304	0.97371	0.97437	13
77	0.97437	0.97502	0.97566	0.97630	0.97692	0.97754	0.97815	12
78	0.97815	0.97875	0.97934	0.97992	0.98050	0.98107	0.98163	11
79	0.98163	0.98218	0.98272	0.98325	0.98378	0.98430	0.98481	10
80	0.98481	0.98531	0.98580	0.98629	0.98676	0.98723	0.98769	9
81	0.98769	0.98814	0.98858	0.98902	0.98944	0.98986	0.99027	8
82	0.99027	0.99067	0.99106	0.99144	0.99182	0.99219	0.99255	7
83	0.99255	0.99290	0.99324	0.99357	0.99390	0.99421	0.99452	6
84	0.99452	0.99482	0.99511	0.99540	0.99567	0.99594	0.99619	5
85	0.99619	0.99644	0.99668	0.99692	0.99714	0.99736	0.99756	4
86	0.99756	0.99776	0.99795	0.99813	0.99831	0.99847	0.99863	3
87	0.99863	0.99878	0.99892	0.99905	0.99917	0.99929	0.99939	2
88	0.99939	0.99949	0.99958	0.99966	0.99973	0.99979	0.99985	1
89°	0.99985	0.99989	0.99993	0.99996	0.99998	1.00000	1.00000	0°
	60′	50′	40′	30′	20′	10′	0′	Angle

NATURAL COSINES

NATURAL TANGENTS

Angle	0′	10′	20′	30′	40′	50′	60′	
0°	0.00000	0.00291	0.00582	0.00873	0.01164	0.01455	0.01746	89°
1	0.01746	0.02036	0.02328	0.02619	0.02910	0.03201	0.03492	88
2	0.03492	0.03783	0.04075	0.04366	0.04658	0.04949	0.05241	87
3	0.05241	0.05533	0.05824	0.06116	0.06408	0.06700	0.06993	86
4	0.06993	0.07285	0.07578	0.07870	0.08163	0.08456	0.08749	85
5	0.08749	0.09042	0.09335	0.09629	0.09923	0.10216	0.10510	84
6	0.10510	0.10805	0.11099	0.11394	0.11688	0.11983	0.12278	83
7	0.12278	0.12574	0.12869	0.13165	0.13461	0.13758	0.14054	82
8	0.14054	0.14351	0.14648	0.14945	0.15243	0.15540	0.15838	81
9	0.15838	0.16137	0.16435	0.16734	0.17033	0.17333	0.17633	80
10	0.17633	0.17933	0.18233	0.18534	0.18835	0.19136	0.19438	79
11	0.19438	0.19740	0.20042	0.20345	0.20648	0.20952	0.21256	78
12	0.21256	0.21560	0.21864	0.22169	0.22475	0.22781	0.23087	77
13	0.23087	0.23393	0.23700	0.24008	0.24316	0.24624	0.24933	76
14	0.24933	0.25242	0.25552	0.25862	0.26172	0.26483	0.26795	75
15	0.26795	0.27107	0.27419	0.27732	0.28046	0.28360	0.28675	74
16	0.28675	0.28990	0.29305	0.29621	0.29938	0.30255	0.30573	73
17	0.30573	0.30891	0.31210	0.31530	0.31850	0.32171	0.32492	72
18	0.32492	0.32814	0.33136	0.33460	0.33783	0.34108	0.34433	71
19	0.34433	0.34758	0.35085	0.35412	0.35740	0.36068	0.36397	70
20	0.36397	0.36727	0.37057	0.37388	0.37720	0.38053	0.38386	69
21	0.38386	0.38721	0.39055	0.39391	0.39727	0.40065	0.40403	68
22	0.40403	0.40741	0.41081	0.41421	0.41763	0.42105	0.42447	67
23	0.42447	0.42791	0.43136	0.43481	0.43828	0.44175	0.44523	66
24	0.44523	0.44872	0.45222	0.45573	0.45924	0.46277	0.46631	65
25	0.46631	0.46985	0.47341	0.47698	0.48055	0.48414	0.48773	64
26	0.48773	0.49134	0.49495	0.49858	0.50222	0.50587	0.50953	63
27	0.50953	0.51320	0.51688	0.52057	0.52427	0.52798	0.53171	62
28	0.53171	0.53545	0.53920	0.54296	0.54673	0.55051	0.55431	61
29	0.55431	0.55812	0.56194	0.56577	0.56962	0.57348	0.57735	60
30	0.57735	0.58124	0.58513	0.58905	0.59297	0.59691	0.60086	59
31	0.60086	0.60483	0.60881	0.61280	0.61681	0.62083	0.62487	58
32	0.62487	0.62892	0.63299	0.63707	0.64117	0.64528	0.64941	57
33	0.64941	0.65355	0.65771	0.66189	0.66608	0.67028	0.67451	56
34	0.67451	0.67875	0.68301	0.68728	0.69157	0.69588	0.70021	55
35	0.70021	0.70455	0.70891	0.71329	0.71769	0.72211	0.72654	54
36	0.72654	0.73100	0.73547	0.73996	0.74447	0.74900	0.75355	53
37	0.75355	0.75812	0.76272	0.76733	0.77196	0.77661	0.78129	52
38	0.78129	0.78598	0.79070	0.79544	0.80020	0.80498	0.80978	51
39	0.80978	0.81461	0.81946	0.82434	0.82923	0.83415	0.83910	50
40	0.83910	0.84407	0.84906	0.85408	0.85912	0.86419	0.86929	49
41	0.86929	0.87441	0.87955	0.88473	0.88992	0.89515	0.90040	48
42	0.90040	0.90569	0.91099	0.91633	0.92170	0.92709	0.93252	47
43	0.93252	0.93797	0.94345	0.94896	0.95451	0.96008	0.96569	46
44°	0.96569	0.97133	0.97700	0.98270	0 98843	0.99420	1.00000	45°
	60′	50′	40′	30′	20′	10′	0′	Angle

NATURAL COTANGENTS

NATURAL TANGENTS

Angle	0′	10′	20′	30′	40′	50′	60′	
45°	1.00000	1.00583	1.01170	1.01761	1.02355	1.02952	1.03553	44°
46	1.03553	1.04158	1.04766	1.05378	1.05994	1.06613	1.07237	43
47	1.07237	1.07864	1.08496	1.09131	1.09770	1.10414	1.11061	42
48	1.11061	1.11713	1.12369	1.13029	1.13694	1.14363	1.15037	41
49	1.15037	1.15715	1.16398	1.17085	1.17777	1.18474	1.19175	40
50	1.19175	1.19882	1.20593	1.21310	1.22031	1.22758	1.23490	39
51	1.23490	1.24227	1.24969	1.25717	1.26471	1.27230	1.27994	38
52	1.27994	1.28764	1.29541	1.30323	1.31110	1.31904	1.32704	37
53	1.32704	1.33511	1.34323	1.35142	1.35968	1.36800	1.37638	36
54	1.37638	1.38484	1.39336	1.40195	1.41061	1.41934	1.42815	35
55	1.42815	1.43703	1.44598	1.45501	1.46411	1.47330	1.48256	34
56	1.48256	1.49190	1.50133	1.51084	1.52043	1.53010	1.53987	33
57	1.53987	1.54972	1.55966	1.56969	1.57981	1.59002	1.60033	32
58	1.60033	1.61074	1.62125	1.63185	1.64256	1.65337	1.66428	31
59	1.66428	1.67530	1.68643	1.69766	1.70901	1.72047	1.73205	30
60	1.73205	1.74375	1.75556	1.76749	1.77955	1.79174	1.80405	29
61	1.80405	1.81649	1.82906	1.84177	1.85462	1.86760	1.88073	28
62	1.88073	1.89400	1.90741	1.92098	1.93470	1.94858	1.96261	27
63	1.96261	1.97681	1.99116	2.00569	2.02039	2.03526	2.05030	26
64	2.05030	2.06553	2.08094	2.09654	2.11233	2.12832	2.14451	25
65	2.14451	2.16090	2.17749	2.19430	2.21132	2.22857	2.24604	24
66	2.24604	2.26374	2.28167	2.29984	2.31826	2.33693	2.35585	23
67	2.35585	2.37504	2.39449	2.41421	2.43422	2.45451	2.47509	22
68	2.47509	2.49597	2.51715	2.53865	2.56046	2.58261	2.60509	21
69	2.60509	2.62791	2.65109	2.67462	2.69853	2.72281	2.74748	20
70	2.74748	2.77254	2.79802	2.82391	2.85023	2.87700	2.90421	19
71	2.90421	2.93189	2.96004	2.98869	3.01783	3.04749	3.07768	18
72	3.07768	3.10842	3.13972	3.17159	3.20406	3.23714	3.27085	17
73	3.27085	3.30521	3.34023	3.37594	3.41236	3.44951	3.48741	16
74	3.48741	3.52609	3.56557	3.60588	3.64705	3.68909	3.73205	15
75	3.73205	3.77595	3.82083	3.86671	3.91364	3.96165	4.01078	14
76	4.01078	4.06107	4.11256	4.16530	4.21933	4.27471	4.33148	13
77	4.33148	4.38969	4.44942	4.51071	4.57363	4.63825	4.70463	12
78	4.70463	4.77286	4.84300	4.91516	4.98940	5.06584	5.14455	11
79	5.14455	5.22566	5.30928	5.39552	5.48451	5.57638	5.67128	10
80	5.67128	5.76937	5.87080	5.97576	6.08444	6.19703	6.31375	9
81	6.31375	6.43484	6.56055	6.69116	6.82694	6.96823	7.11537	8
82	7.11537	7.26873	7.42871	7.59575	7.77035	7.95302	8.14435	7
83	8.14435	8.34496	8.55555	8.77689	9.00983	9.25530	9.51436	6
84	9.51436	9.78817	10.07803	10.38540	10.71191	11.05943	11.43005	5
85	11.43005	11.82617	12.25051	12.70621	13.19688	13.72674	14.30067	4
86	14.30067	14.92442	15.60478	16.34986	17.16934	18.07498	19.08114	3
87	19.08114	20.20555	21.47040	22.90377	24.54176	26.43160	28.63625	2
88	28.63625	31.24158	34.36777	38.18846	42.96408	49.10388	57.28996	1
89°	57.28996	68.75009	85.93979	114.58865	171.88540	343.77371	Infinite.	0°
	60′	50′	40′	30′	20′	10′	0′	Angle

NATURAL COTANGENTS

NATURAL SECANTS

Angle	0′	10′	20′	30′	40′	50′	60′	
0°	1.00000	1.00001	1.00002	1.00004	1.00007	1.00011	1.00015	89°
1	1.00015	1.00021	1.00027	1.00034	1.00042	1.00051	1.00061	88
2	1.00061	1.00072	1.00083	1.00095	1.00108	1.00122	1.00137	87
3	1.00137	1.00153	1.00169	1.00187	1.00205	1.00224	1.00244	86
4	1.00244	1.00265	1.00287	1.00309	1.00333	1.00357	1.00382	85
5	1.00382	1.00408	1.00435	1.00463	1.00491	1.00521	1.00551	84
6	1.00551	1.00582	1.00614	1.00647	1.00681	1.00715	1.00751	83
7	1.00751	1.00787	1.00825	1.00863	1.00902	1.00942	1.00983	82
8	1.00983	1.01024	1.01067	1.01111	1.01155	1.01200	1.01247	81
9	1.01247	1.01294	1.01342	1.01391	1.01440	1.01491	1.01543	80
10	1.01543	1.01595	1.01649	1.01703	1.01758	1.01815	1.01872	79
11	1.01872	1.01930	1.01989	1.02049	1.02110	1.02171	1.02234	78
12	1.02234	1.02298	1.02362	1.02428	1.02494	1.02562	1.02630	77
13	1.02630	1.02700	1.02770	1.02842	1.02914	1.02987	1.03061	76
14	1.03061	1.03137	1.03213	1.03290	1.03368	1.03447	1.03528	75
15	1.03528	1.03609	1.03691	1.03774	1.03858	1.03944	1.04030	74
16	1.04030	1.04117	1.04206	1.04295	1.04385	1.04477	1.04569	73
17	1.04569	1.04663	1.04757	1.04853	1.04950	1.05047	1.05146	72
18	1.05146	1.05246	1.05347	1.05449	1.05552	1.05657	1.05762	71
19	1.05762	1.05869	1.05976	1.06085	1.06195	1.06306	1.06418	70
20	1.06418	1.06531	1.06645	1.06761	1.06878	1.06995	1.07115	69
21	1.07115	1.07235	1.07356	1.07479	1.07602	1.07727	1.07853	68
22	1.07853	1.07981	1.08109	1.08239	1.08370	1.08503	1.08636	67
23	1.08636	1.08771	1.08907	1.09044	1.09183	1.09323	1.09464	66
24	1.09464	1.09606	1.09750	1.09895	1.10041	1.10189	1.10338	65
25	1.10338	1.10488	1.10640	1.10793	1.10947	1.11103	1.11260	64
26	1.11260	1.11419	1.11579	1.11740	1.11903	1.12067	1.12233	63
27	1.12233	1.12400	1.12568	1.12738	1.12910	1.13083	1.13257	62
28	1.13257	1.13433	1.13610	1.13789	1.13970	1.14152	1.14335	61
29	1.14335	1.14521	1.14707	1.14896	1.15085	1.15277	1.15470	60
30	1.15470	1.15665	1.15861	1.16059	1.16259	1.16460	1.16663	59
31	1.16663	1.16868	1.17075	1.17283	1.17493	1.17704	1.17918	58
32	1.17918	1.18133	1.18350	1.18569	1.18790	1.19012	1.19236	57
33	1.19236	1.19463	1.19691	1.19920	1.20152	1.20386	1.20622	56
34	1.20622	1.20859	1.21099	1.21341	1.21584	1.21830	1.22077	55
35	1.22077	1.22327	1.22579	1.22833	1.23089	1.23347	1.23607	54
36	1.23607	1.23869	1.24134	1.24400	1.24669	1.24940	1.25214	53
37	1.25214	1.25489	1.25767	1.26047	1.26330	1.26615	1.26902	52
38	1.26902	1.27191	1.27483	1.27778	1.28075	1.28374	1.28676	51
39	1.28676	1.28980	1.29287	1.29597	1.29909	1.30223	1.30541	50
40	1.30541	1.30861	1.31183	1.31509	1.31837	1.32168	1.32501	49
41	1.32501	1.32838	1.33177	1.33519	1.33864	1.34212	1.34563	48
42	1.34563	1.34917	1.35274	1.35634	1.35997	1.36363	1.36733	47
43	1.36733	1.37105	1.37481	1.37860	1.38242	1.38628	1.39016	46
44°	1.39016	1.39409	1.39804	1.40203	1.40606	1.41012	1.41421	45°
	60′	50′	40′	30′	20′	10′	0′	Angle

NATURAL COSECANTS

NATURAL SECANTS

Angle	0′	10′	20′	30′	40′	50′	60′	
45°	1.41421	1.41835	1.42251	1.42672	1.43096	1.43524	1.43956	44°
46	1.43956	1.44391	1.44831	1.45274	1.45721	1.46173	1.46628	43
47	1.46628	1.47087	1.47551	1.48019	1.48491	1.48967	1.49448	42
48	1.49448	1.49933	1.50422	1.50916	1.51415	1.51918	1.52425	41
49	1.52425	1.52938	1.53455	1.53977	1.54504	1.55036	1.55572	40
50	1.55572	1.56114	1.56661	1.57213	1.57771	1.58333	1.58902	39
51	1.58902	1.59475	1.60054	1.60639	1.61229	1.61825	1.62427	38
52	1.62427	1.63035	1.63648	1.64268	1.64894	1.65526	1.66164	37
53	1.66164	1.66809	1.67460	1.68117	1.68782	1.69452	1.70130	36
54	1.70130	1.70815	1.71506	1.72205	1.72911	1.73624	1.74345	35
55	1.74345	1.75073	1.75808	1.76552	1.77303	1.78062	1.78829	34
56	1.78829	1.79604	1.80388	1.81180	1.81981	1.82790	1.83608	33
57	1.83608	1.84435	1.85271	1.86116	1.86970	1.87834	1.88708	32
58	1.88708	1.89591	1.90485	1.91388	1.92302	1.93226	1.94160	31
59	1.94160	1.95106	1.96062	1.97029	1.98008	1.98998	2.00000	30
60	2.00000	2.01014	2.02039	2.03077	2.04128	2.05191	2.06267	29
61	2.06267	2.07356	2.08458	2.09574	2.10704	2.11847	2.13005	28
62	2.13005	2.14178	2.15366	2.16568	2.17786	2.19019	2.20269	27
63	2.20269	2.21535	2.22817	2.24116	2.25432	2.26766	2.28117	26
64	2.28117	2.29487	2.30875	2.32282	2.33708	2.35154	2.36620	25
65	2.36620	2.38107	2.39614	2.41142	2.42692	2.44264	2.45859	24
66	2.45859	2.47477	2.49119	2.50784	2.52474	2.54190	2.55930	23
67	2.55930	2.57698	2.59491	2.61313	2.63162	2.65040	2.66947	22
68	2.66947	2.68884	2.70851	2.72850	2.74881	2.76945	2.79043	21
69	2.79043	2.81175	2.83342	2.85545	2.87785	2.90063	2.92380	20
70	2.92380	2.94737	2.97135	2.99574	3.02057	3.04584	3.07155	19
71	3.07155	3.09774	3.12440	3.15155	3.17920	3.20737	3.23607	18
72	3.23607	3.26531	3.29512	3.32551	3.35649	3.38808	3.42030	17
73	3.42030	3.45317	3.48671	3.52094	3.55587	3.59154	3.62796	16
74	3.62796	3.66515	3.70315	3.74198	3.78166	3.82223	3.86370	15
75	3.86370	3.90613	3.94952	3.99393	4.03938	4.08591	4.13357	14
76	4.13357	4.18238	4.23239	4.28366	4.33622	4.39012	4.44541	13
77	4.44541	4.50216	4.56041	4.62023	4.68167	4.74482	4.80973	12
78	4.80973	4.87649	4.94517	5.01585	5.08863	5.16359	5.24084	11
79	5.24084	5.32049	5.40263	5.48740	5.57493	5.66533	5.75877	10
80	5.75877	5.85539	5.95536	6.05886	6.16607	6.27719	6.39245	9
81	6.39245	6.51208	6.63633	6.76547	6.89979	7.03962	7.18530	8
82	7.18530	7.33719	7.49571	7.66130	7.83443	8.01565	8.20551	7
83	8.20551	8.40466	8.61379	8.83367	9.06515	9.30917	9.56677	6
84	9.56677	9.83912	10.12752	10.43343	10.75849	11.10455	11.47371	5
85	11.47371	11.86837	12.29125	12.74550	13.23472	13.76312	14.33559	4
86	14.33559	14.95788	15.63679	16.38041	17.19843	18.10262	19.10732	3
87	19.10732	20.23028	21.49368	22.92559	24.56212	26.45051	28.65371	2
88	28.65371	31.25758	34.38232	38.20155	42.97571	49.11406	57.29869	1
89°	57.29869	68.75736	85.94561	114.59301	171.88831	343.77516	Infinite.	0°
	60′	50′	40′	30′	20′	10′	0′	Angle

NATURAL COSECANTS

.01

.49

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
.01	.0001	.000001	0.1000	0.2154	$\bar{2}.00000$	100000.000	.03142	.000079
.02	.0004	.000008	0.1414	0.2714	$\bar{2}.30103$	50000.000	.06283	.000314
.03	.0009	.000027	0.1732	0.3107	$\bar{2}.47712$	33333.333	.09425	.000707
.04	.0016	.000064	0.2000	0.3420	$\bar{2}.60206$	25000.000	.12566	.001257
.05	.0025	.000125	0.2236	0.3684	$\bar{2}.69897$	20000.000	.15708	.001964
.06	.0036	.000216	0.2449	0.3915	$\bar{2}.77815$	16666.667	.18850	.002827
.07	.0049	.000343	0.2646	0.4121	$\bar{2}.84510$	14285.714	.21991	.003849
.08	.0064	.000512	0.2828	0.4309	$\bar{2}.90309$	12500.000	.25133	.005027
.09	.0081	.000729	0.3000	0.4481	$\bar{2}.95424$	11111.111	.28274	.006362
.10	.0100	.001000	0.3162	0.4642	$\bar{1}.00000$	10000.000	.31416	.007854
.11	.0121	.001331	0.3317	0.4791	$\bar{1}.04139$	9090.909	.34558	.009503
.12	.0144	.001728	0.3464	0.4932	$\bar{1}.07918$	8333.333	.37699	.011310
.13	.0169	.002197	0.3606	0.5066	$\bar{1}.11394$	7692.308	.40841	.013273
.14	.0196	.002744	0.3742	0.5192	$\bar{1}.14613$	7142.857	.43982	.015394
.15	.0225	.003375	0.3873	0.5313	$\bar{1}.17609$	6666.667	.47124	.017672
.16	.0256	.004096	0.4000	0.5429	$\bar{1}.20412$	6250.000	.50265	.020106
.17	.0289	.004913	0.4123	0.5540	$\bar{1}.23045$	5882.353	.53407	.022698
.18	.0324	.005832	0.4243	0.5646	$\bar{1}.25527$	5555.556	.56549	.025447
.19	.0361	.006859	0.4359	0.5749	$\bar{1}.27875$	5263.158	.59690	.028353
.20	.0400	.008000	0.4472	0.5848	$\bar{1}.30103$	5000.000	.62832	.031416
.21	.0441	.009261	0.4583	0.5944	$\bar{1}.32222$	4761.905	.65973	.034636
.22	.0484	.010648	0.4690	0.6037	$\bar{1}.34242$	4545.455	.69115	.038013
.23	.0529	.012167	0.4796	0.6127	$\bar{1}.36173$	4347.826	.72257	.041548
.24	.0576	.013824	0.4899	0.6214	$\bar{1}.38021$	4166.667	.75398	.045239
.25	.0625	.015625	0.5000	0.6300	$\bar{1}.39794$	4000.000	.78540	.049087
.26	.0676	.017576	0.5099	0.6383	$\bar{1}.41497$	3846.154	.81681	.053093
.27	.0729	.019683	0.5196	0.6463	$\bar{1}.43136$	3703.704	.84823	.057256
.28	.0784	.021952	0.5292	0.6542	$\bar{1}.44716$	3571.429	.87965	.061575
.29	.0841	.024389	0.5385	0.6619	$\bar{1}.46240$	3448.276	.91106	.066052
.30	.0900	.027000	0.5477	0.6694	$\bar{1}.47712$	3333.333	.94248	.070686
.31	.0961	.029791	0.5568	0.6768	$\bar{1}.49136$	3225.807	.97389	.075477
.32	.1024	.032768	0.5657	0.6840	$\bar{1}.50515$	3125.000	1.00531	.080425
.33	.1089	.035937	0.5745	0.6910	$\bar{1}.51851$	3030.303	1.03673	.085530
.34	.1156	.039304	0.5831	0.6980	$\bar{1}.53148$	2941.177	1.06814	.090792
.35	.1225	.042875	0.5916	0.7047	$\bar{1}.54407$	2857.143	1.09956	.096211
.36	.1296	.046656	0.6000	0.7114	$\bar{1}.55630$	2777.778	1.13097	.101788
.37	.1369	.050653	0.6083	0.7179	$\bar{1}.56820$	2702.703	1.16239	.107521
.38	.1444	.054872	0.6164	0.7243	$\bar{1}.57978$	2631.579	1.19381	.113411
.39	.1521	.059319	0.6245	0.7306	$\bar{1}.59106$	2564.103	1.22522	.119459
.40	.1600	.064000	0.6325	0.7368	$\bar{1}.60206$	2500.000	1.2566	.125664
.41	.1681	.068921	0.6403	0.7429	$\bar{1}.61278$	2439.024	1.2881	.132025
.42	.1764	.074088	0.6481	0.7489	$\bar{1}.62325$	2380.952	1.3195	.138544
.43	.1849	.079507	0.6557	0.7548	$\bar{1}.63347$	2325.581	1.3509	.145220
.44	.1936	.085184	0.6633	0.7606	$\bar{1}.64345$	2272.727	1.3823	.152053
.45	.2025	.091125	0.6708	0.7663	$\bar{1}.65321$	2222.222	1.4137	.159043
.46	.2116	.097336	0.6782	0.7719	$\bar{1}.66276$	2173.913	1.4451	.166190
.47	.2209	.103823	0.6856	0.7775	$\bar{1}.67210$	2127.660	1.4765	.173494
.48	.2304	.110592	0.6928	0.7830	$\bar{1}.68124$	2083.333	1.5080	.180956
.49	.2401	.117649	0.7000	0.7884	$\bar{1}.69020$	2040.816	1.5394	.188574

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
.50	.2500	.125000	0.7071	0.7937	$\bar{1}$.69897	2000.000	1.5708	.19635
.51	.2601	.132651	0.7141	0.7990	$\bar{1}$.70757	1960.784	1.6022	.20428
.52	.2704	.140608	0.7211	0.8041	$\bar{1}$.71600	1923.077	1.6336	.21237
.53	.2809	.148877	0.7280	0.8093	$\bar{1}$.72428	1886.793	1.6650	.22062
.54	.2916	.157464	0.7348	0.8143	$\bar{1}$.73239	1851.852	1.6965	.22902
.55	.3025	.166375	0.7416	0.8193	$\bar{1}$.74036	1818.182	1.7279	.23758
.56	.3136	.175616	0.7483	0.8243	$\bar{1}$.74819	1785.714	1.7593	.24630
.57	.3249	.185193	0.7550	0.8291	$\bar{1}$.75587	1754.386	1.7907	.25518
.58	.3364	.195112	0.7616	0.8340	$\bar{1}$.76343	1724.138	1.8221	.26421
.59	.3481	.205379	0.7681	0.8387	$\bar{1}$.77085	1694.915	1.8535	.27340
.60	.3600	.216000	0.7746	0.8434	$\bar{1}$.77815	1666.667	1.8850	.28274
.61	.3721	.226981	0.7810	0.8481	$\bar{1}$.78533	1639.344	1.9164	.29225
.62	.3844	.238328	0.7874	0.8527	$\bar{1}$.79239	1612.903	1.9478	.30191
.63	.3969	.250047	0.7937	0.8573	$\bar{1}$.79934	1587.302	1.9792	.31173
.64	.4096	.262144	0.8000	0.8618	$\bar{1}$.80618	1562.500	2.0106	.32170
.65	.4225	.274625	0.8062	0.8662	$\bar{1}$.81291	1538.462	2.0420	.33183
.66	.4356	.287496	0.8124	0.8707	$\bar{1}$.81954	1515.152	2.0735	.34212
.67	.4489	.300763	0.8185	0.8750	$\bar{1}$.82607	1492.537	2.1049	.35257
.68	.4624	.314432	0.8246	0.8794	$\bar{1}$.83251	1470.588	2.1363	.36317
.69	.4761	.328509	0.8307	0.8837	$\bar{1}$.83885	1449.275	2.1677	.37393
.70	.4900	.343000	0.8367	0.8879	$\bar{1}$.84510	1428.571	2.1991	.38485
.71	.5041	.357911	0.8426	0.8921	$\bar{1}$.85126	1408.451	2.2305	.39592
.72	.5184	.373248	0.8485	0.8963	$\bar{1}$.85733	1388.889	2.2620	.40715
.73	.5329	.389017	0.8544	0.9004	$\bar{1}$.86332	1369.863	2.2934	.41854
.74	.5476	.405224	0.8602	0.9045	$\bar{1}$.86923	1351.351	2.3248	.43008
.75	.5625	.421875	0.8660	0.9086	$\bar{1}$.87506	1333.333	2.3562	.44179
.76	.5776	.438976	0.8718	0.9126	$\bar{1}$.88081	1315.790	2.3876	.45365
.77	.5929	.456533	0.8775	0.9166	$\bar{1}$.88649	1298.701	2.4190	.46566
.78	.6084	.474552	0.8832	0.9205	$\bar{1}$.89209	1282.051	2.4504	.47784
.79	.6241	.493039	0.8888	0.9244	$\bar{1}$.89763	1265.823	2.4819	.49017
.80	.6400	.512000	0.8944	0.9283	$\bar{1}$.90309	1250.000	2.5133	.50266
.81	.6561	.531441	0.9000	0.9322	$\bar{1}$.90849	1234.568	2.5447	.51530
.82	.6724	.551368	0.9055	0.9360	$\bar{1}$.91381	1219.512	2.5761	.52810
.83	.6889	.571787	0.9110	0.9398	$\bar{1}$.91908	1204.819	2.6075	.54106
.84	.7056	.592704	0.9165	0.9435	$\bar{1}$.92428	1190.476	2.6389	.55418
.85	.7225	.614125	0.9220	0.9473	$\bar{1}$.92942	1176.471	2.6704	.56745
.86	.7396	.636056	0.9274	0.9510	$\bar{1}$.93450	1162.791	2.7018	.58088
.87	.7569	.658503	0.9327	0.9546	$\bar{1}$.93952	1149.425	2.7332	.59447
.88	.7744	.681472	0.9381	0.9583	$\bar{1}$.94448	1136.364	2.7646	.60821
.89	.7921	.704969	0.9434	0.9619	$\bar{1}$.94939	1123.596	2.7960	.62211
.90	.8100	.729000	0.9487	0.9655	$\bar{1}$.95424	1111.111	2.8274	.63617
.91	.8281	.753571	0.9539	0.9691	$\bar{1}$.95904	1098.901	2.8589	.65039
.92	.8464	.778688	0.9592	0.9726	$\bar{1}$.96379	1086.957	2.8903	.66476
.93	.8649	.804357	0.9644	0.9761	$\bar{1}$.96848	1075.269	2.9217	.67929
.94	.8836	.830584	0.9695	0.9796	$\bar{1}$.97313	1063.830	2.9531	.69398
.95	.9025	.857375	0.9747	0.9830	$\bar{1}$.97772	1052.632	2.9845	.70882
.96	.9216	.884736	0.9798	0.9865	$\bar{1}$.98227	1041.667	3.0159	.72382
.97	.9409	.912673	0.9849	0.9899	$\bar{1}$.98677	1030.928	3.0473	.73898
.98	.9604	.941192	0.9899	0.9933	$\bar{1}$.99123	1020.408	3.0788	.75430
.99	.9801	.970299	0.9950	0.9967	$\bar{1}$.99564	1010.101	3.1102	.76977

1

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FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
1	1	1	1.0000	1.0000	0.00000	1000.000	3.142	0.7854
2	4	8	1.4142	1.2599	0.30103	500.000	6.283	3.1416
3	9	27	1.7321	1.4422	0.47712	333.333	9.425	7.0686
4	16	64	2.0000	1.5874	0.60206	250.000	12.566	12.5664
5	25	125	2.2361	1.7100	0.69897	200.000	15.708	19.6350
6	36	216	2.4495	1.8171	0.77815	166.667	18.850	28.2743
7	49	343	2.6458	1.9129	0.84510	142.857	21.991	38.4845
8	64	512	2.8284	2.0000	0.90309	125.000	25.133	50.2655
9	81	729	3.0000	2.0801	0.95424	111.111	28.274	63.6173
10	100	1000	3.1623	2.1544	1.00000	100.000	31.416	78.5398
11	121	1331	3.3166	2.2240	1.04139	90.9091	34.558	95.0332
12	144	1728	3.4641	2.2894	1.07918	83.3333	37.699	113.097
13	169	2197	3.6056	2.3513	1.11394	76.9231	40.841	132.732
14	196	2744	3.7417	2.4101	1.14613	71.4286	43.982	153.938
15	225	3375	3.8730	2.4662	1.17609	66.6667	47.124	176.715
16	256	4096	4.0000	2.5198	1.20412	62.5000	50.265	201.062
17	289	4913	4.1231	2.5713	1.23045	58.8235	53.407	226.980
18	324	5832	4.2426	2.6207	1.25527	55.5556	56.549	254.469
19	361	6859	4.3589	2.6684	1.27875	52.6316	59.690	283.529
20	400	8000	4.4721	2.7144	1.30103	50.0000	62.832	314.159
21	441	9261	4.5826	2.7589	1.32222	47.6190	65.973	346.361
22	484	10648	4.6904	2.8020	1.34242	45.4545	69.115	380.133
23	529	12167	4.7958	2.8439	1.36173	43.4783	72.257	415.476
24	576	13824	4.8990	2.8845	1.38021	41.6667	75.398	452.389
25	625	15625	5.0000	2.9240	1.39794	40.0000	78.540	490.874
26	676	17576	5.0990	2.9625	1.41497	38.4615	81.681	530.929
27	729	19683	5.1962	3.0000	1.43136	37.0370	84.823	572.555
28	784	21952	5.2915	3.0366	1.44716	35.7143	87.965	615.752
29	841	24389	5.3852	3.0723	1.46240	34.4828	91.106	660.520
30	900	27000	5.4772	3.1072	1.47712	33.3333	94.248	706.858
31	961	29791	5.5678	3.1414	1.49136	32.2581	97.389	754.768
32	1024	32768	5.6569	3.1748	1.50515	31.2500	100.531	804.248
33	1089	35937	5.7446	3.2075	1.51851	30.3030	103.673	855.299
34	1156	39304	5.8310	3.2396	1.53148	29.4118	106.814	907.920
35	1225	42875	5.9161	3.2711	1.54407	28.5714	109.956	962.113
36	1296	46656	6.0000	3.3019	1.55630	27.7778	113.097	1017.88
37	1369	50653	6.0828	3.3322	1.56820	27.0270	116.239	1075.21
38	1444	54872	6.1644	3.3620	1.57978	26.3158	119.381	1134.11
39	1521	59319	6.2450	3.3912	1.59106	25.6410	122.522	1194.59
40	1600	64000	6.3246	3.4200	1.60206	25.0000	125.66	1256.64
41	1681	68921	6.4031	3.4482	1.61278	24.3902	128.81	1320.25
42	1764	74088	6.4807	3.4760	1.62325	23.8095	131.95	1385.44
43	1849	79507	6.5574	3.5034	1.63347	23.2558	135.09	1452.20
44	1936	85184	6.6332	3.5303	1.64345	22.7273	138.23	1520.53
45	2025	91125	6.7082	3.5569	1.65321	22.2222	141.37	1590.43
46	2116	97336	6.7823	3.5830	1.66276	21.7391	144.51	1661.90
47	2209	103823	6.8557	3.6088	1.67210	21.2766	147.65	1734.94
48	2304	110592	6.9282	3.6342	1.68124	20.8333	150.80	1809.56
49	2401	117649	7.0000	3.6593	1.69020	20.4082	153.94	1885.74

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
50	2500	125000	7.0711	3.6840	1.69897	20.0000	157.08	1963.50
51	2601	132651	7.1414	3.7084	1.70757	19.6078	160.22	2042.82
52	2704	140608	7.2111	3.7325	1.71600	19.2308	163.36	2123.72
53	2809	148877	7.2801	3.7563	1.72428	18.8679	166.50	2206.18
54	2916	157464	7.3485	3.7798	1.73239	18.5185	169.65	2290.22
55	3025	166375	7.4162	3.8030	1.74036	18.1818	172.79	2375.83
56	3136	175616	7.4833	3.8259	1.74819	17.8571	175.93	2463.01
57	3249	185193	7.5498	3.8485	1.75587	17.5439	179.07	2551.76
58	3364	195112	7.6158	3.8709	1.76343	17.2414	182.21	2642.08
59	3481	205379	7.6811	3.8930	1.77085	16.9492	185.35	2733.97
60	3600	216000	7.7460	3.9149	1.77815	16.6667	188.50	2827.43
61	3721	226981	7.8102	3.9365	1.78533	16.3934	191.64	2922.47
62	3844	238328	7.8740	3.9579	1.79239	16.1290	194.78	3019.07
63	3969	250047	7.9373	3.9791	1.79934	15.8730	197.92	3117.25
64	4096	262144	8.0000	4.0000	1.80618	15.6250	201.06	3216.99
65	4225	274625	8.0623	4.0207	1.81291	15.3846	204.20	3318.31
66	4356	287496	8.1240	4.0412	1.81954	15.1515	207.35	3421.19
67	4489	300763	8.1854	4.0615	1.82607	14.9254	210.49	3525.65
68	4624	314432	8.2462	4.0817	1.83251	14.7059	213.63	3631.68
69	4761	328509	8.3066	4.1016	1.83885	14.4928	216.77	3739.28
70	4900	343000	8.3666	4.1213	1.84510	14.2857	219.91	3848.45
71	5041	357911	8.4261	4.1408	1.85126	14.0845	223.05	3959.19
72	5184	373248	8.4853	4.1602	1.85733	13.8889	226.19	4071.50
73	5329	389017	8.5440	4.1793	1.86332	13.6986	229.34	4185.39
74	5476	405224	8.6023	4.1983	1.86923	13.5135	232.48	4300.84
75	5625	421875	8.6603	4.2172	1.87506	13.3333	235.62	4417.86
76	5776	438976	8.7178	4.2358	1.88081	13.1579	238.76	4536.46
77	5929	456533	8.7750	4.2543	1.88649	12.9870	241.90	4656.63
78	6084	474552	8.8318	4.2727	1.89209	12.8205	245.04	4778.36
79	6241	493039	8.8882	4.2908	1.89763	12.6582	248.19	4901.67
80	6400	512000	8.9443	4.3089	1.90309	12.5000	251.33	5026.55
81	6561	531441	9.0000	4.3267	1.90849	12.3457	254.47	5153.00
82	6724	551368	9.0554	4.3445	1.91381	12.1951	257.61	5281.02
83	6889	571787	9.1104	4.3621	1.91908	12.0482	260.75	5410.61
84	7056	592704	9.1652	4.3795	1.92428	11.9048	263.89	5541.77
85	7225	614125	9.2195	4.3968	1.92942	11.7647	267.04	5674.50
86	7396	636056	9.2736	4.4140	1.93450	11.6279	270.18	5808.80
87	7569	658503	9.3274	4.4310	1.93952	11.4943	273.32	5944.68
88	7744	681472	9.3808	4.4480	1.94448	11.3636	276.46	6082.12
89	7921	704969	9.4340	4.4647	1.94939	11.2360	279.60	6221.14
90	8100	729000	9.4868	4.4814	1.95424	11.1111	282.74	6361.73
91	8281	753571	9.5394	4.4979	1.95904	10.9890	285.88	6503.88
92	8464	778688	9.5917	4.5144	1.96379	10.8696	289.03	6647.61
93	8649	804357	9.6437	4.5307	1.96848	10.7527	292.17	6792.91
94	8836	830584	9.6954	4.5468	1.97313	10.6383	295.31	6939.78
95	9025	857375	9.7468	4.5629	1.97772	10.5263	298.45	7088.22
96	9216	884736	9.7980	4.5789	1.98227	10.4167	301.59	7238.23
97	9409	912673	9.8489	4.5947	1.98677	10.3093	304.73	7389.81
98	9604	941192	9.8995	4.6104	1.99123	10.2041	307.88	7542.96
99	9801	970299	9.9499	4.6261	1.99564	10.1010	311.02	7697.69

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FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
100	10000	1000000	10.0000	4.6416	2.00000	10.0000	314.16	7853.98
101	10201	1030301	10.0499	4.6570	2.00432	9.90099	317.30	8011.85
102	10404	1061208	10.0995	4.6723	2.00860	9.80392	320.44	8171.28
103	10609	1092727	10.1489	4.6875	2.01284	9.70874	323.58	8332.29
104	10816	1124864	10.1980	4.7027	2.01703	9.61538	326.73	8494.87
105	11025	1157625	10.2470	4.7177	2.02119	9.52381	329.87	8659.01
106	11236	1191016	10.2956	4.7326	2.02531	9.43396	333.01	8824.73
107	11449	1225043	10.3441	4.7475	2.02938	9.34579	336.15	8992.02
108	11664	1259712	10.3923	4.7622	2.03342	9.25926	339.29	9160.88
109	11881	1295029	10.4403	4.7769	2.03743	9.17431	342.43	9331.32
110	12100	1331000	10.4881	4.7914	2.04139	9.09091	345.58	9503.32
111	12321	1367631	10.5357	4.8059	2.04532	9.00901	348.72	9676.89
112	12544	1404928	10.5830	4.8203	2.04922	8.92857	351.86	9852.03
113	12769	1442897	10.6301	4.8346	2.05308	8.84956	355.00	10028.7
114	12996	1481544	10.6771	4.8488	2.05690	8.77193	358.14	10207.0
115	13225	1520875	10.7238	4.8629	2.06070	8.69565	361.28	10386.9
116	13456	1560896	10.7703	4.8770	2.06446	8.62069	364.42	10568.3
117	13689	1601613	10.8167	4.8910	2.06819	8.54701	367.57	10751.3
118	13924	1643032	10.8628	4.9049	2.07188	8.47458	370.71	10935.9
119	14161	1685159	10.9087	4.9187	2.07555	8.40336	373.85	11122.0
120	14400	1728000	10.9545	4.9324	2.07918	8.33333	376.99	11309.7
121	14641	1771561	11.0000	4.9461	2.08279	8.26446	380.13	11499.0
122	14884	1815848	11.0454	4.9597	2.08636	8.19672	383.27	11689.9
123	15129	1860867	11.0905	4.9732	2.08991	8.13008	386.42	11882.3
124	15376	1906624	11.1355	4.9866	2.09342	8.06452	389.56	12076.3
125	15625	1953125	11.1803	5.0000	2.09691	8.00000	392.70	12271.8
126	15876	2000376	11.2250	5.0133	2.10037	7.93651	395.84	12469.0
127	16129	2048383	11.2694	5.0265	2.10380	7.87402	398.98	12667.7
128	16384	2097152	11.3137	5.0397	2.10721	7.81250	402.12	12868.0
129	16641	2146689	11.3578	5.0528	2.11059	7.75194	405.27	13069.8
130	16900	2197000	11.4018	5.0658	2.11394	7.69231	408.41	13273.2
131	17161	2248091	11.4455	5.0788	2.11727	7.63359	411.55	13478.2
132	17424	2299968	11.4891	5.0916	2.12057	7.57576	414.69	13684.8
133	17689	2352637	11.5326	5.1045	2.12385	7.51880	417.83	13892.9
134	17956	2406104	11.5758	5.1172	2.12710	7.46269	420.97	14102.6
135	18225	2460375	11.6190	5.1299	2.13033	7.40741	424.12	14313.9
136	18496	2515456	11.6619	5.1426	2.13354	7.35294	427.26	14526.7
137	18769	2571353	11.7047	5.1551	2.13672	7.29927	430.40	14741.1
138	19044	2628072	11.7473	5.1676	2.13988	7.24638	433.54	14957.1
139	19321	2685619	11.7898	5.1801	2.14301	7.19424	436.68	15174.7
140	19600	2744000	11.8322	5.1925	2.14613	7.14286	439.82	15393.8
141	19881	2803221	11.8743	5.2048	2.14922	7.09220	442.96	15614.5
142	20164	2863288	11.9164	5.2171	2.15229	7.04225	446.11	15836.8
143	20449	2924207	11.9583	5.2293	2.15534	6.99301	449.25	16060.6
144	20736	2985984	12.0000	5.2415	2.15836	6.94444	452.39	16286.0
145	21025	3048625	12.0416	5.2536	2.16137	6.89655	455.53	16513.0
146	21316	3112136	12.0830	5.2656	2.16435	6.84932	458.67	16741.5
147	21609	3176523	12.1244	5.2776	2.16732	6.80272	461.81	16971.7
148	21904	3241792	12.1655	5.2896	2.17026	6.75676	464.96	17203.4
149	22201	3307949	12.2066	5.3015	2.17319	6.71141	468.10	17436.6

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
150	22500	3375000	12.2474	5.3133	2.17609	6.66667	471.24	17671.5
151	22801	3442951	12.2882	5.3251	2.17898	6.62252	474.38	17907.9
152	23104	3511808	12.3288	5.3368	2.18184	6.57895	477.52	18145.8
153	23409	3581577	12.3693	5.3485	2.18469	6.53595	480.66	18385.4
154	23716	3652264	12.4097	5.3601	2.18752	6.49351	483.81	18626.5
155	24025	3723875	12.4499	5.3717	2.19033	6.45161	486.95	18869.2
156	24336	3796416	12.4900	5.3832	2.19312	6.41026	490.09	19113.4
157	24649	3869893	12.5300	5.3947	2.19590	6.36943	493.23	19359.3
158	24964	3944312	12.5698	5.4061	2.19866	6.32911	496.37	19606.7
159	25281	4019679	12.6095	5.4175	2.20140	6.28931	499.51	19855.7
160	25600	4096000	12.6491	5.4288	2.20412	6.25000	502.65	20106.2
161	25921	4173281	12.6886	5.4401	2.20683	6.21118	505.80	20358.3
162	26244	4251528	12.7279	5.4514	2.20952	6.17284	508.94	20612.0
163	26569	4330747	12.7671	5.4626	2.21219	6.13497	512.08	20867.2
164	26896	4410944	12.8062	5.4737	2.21484	6.09756	515.22	21124.1
165	27225	4492125	12.8452	5.4848	2.21748	6.06061	518.36	21382.5
166	27556	4574296	12.8841	5.4959	2.22011	6.02410	521.50	21642.4
167	27889	4657463	12.9228	5.5069	2.22272	5.98802	524.65	21904.0
168	28224	4741632	12.9615	5.5178	2.22531	5.95238	527.79	22167.1
169	28561	4826809	13.0000	5.5288	2.22789	5.91716	530.93	22431.8
170	28900	4913000	13.0384	5.5397	2.23045	5.88235	534.07	22698.0
171	29241	5000211	13.0767	5.5505	2.23300	5.84795	537.21	22965.8
172	29584	5088448	13.1149	5.5613	2.23553	5.81395	540.35	23235.2
173	29929	5177717	13.1529	5.5721	2.23805	5.78035	543.50	23506.2
174	30276	5268024	13.1909	5.5828	2.24055	5.74713	546.64	23778.7
175	30625	5359375	13.2288	5.5934	2.24304	5.71429	549.78	24052.8
176	30976	5451776	13.2665	5.6041	2.24551	5.68182	552.92	24328.5
177	31329	5545233	13.3041	5.6147	2.24797	5.64972	556.06	24605.7
178	31684	5639752	13.3417	5.6252	2.25042	5.61798	559.20	24884.6
179	32041	5735339	13.3791	5.6357	2.25285	5.58659	562.35	25164.9
180	32400	5832000	13.4164	5.6462	2.25527	5.55556	565.49	25446.9
181	32761	5929741	13.4536	5.6567	2.25768	5.52486	568.63	25730.4
182	33124	6028568	13.4907	5.6671	2.26007	5.49451	571.77	26015.5
183	33489	6128487	13.5277	5.6774	2.26245	5.46448	574.91	26302.2
184	33856	6229504	13.5647	5.6877	2.26482	5.43478	578.05	26590.4
185	34225	6331625	13.6015	5.6980	2.26717	5.40541	581.19	26880.3
186	34596	6434856	13.6382	5.7083	2.26951	5.37634	584.34	27171.6
187	34969	6539203	13.6748	5.7185	2.27184	5.34759	587.48	27464.6
188	35344	6644672	13.7113	5.7287	2.27416	5.31915	590.62	27759.1
189	35721	6751269	13.7477	5.7388	2.27646	5.29101	593.76	28055.2
190	36100	6859000	13.7840	5.7489	2.27875	5.26316	596.90	28352.9
191	36481	6967871	13.8203	5.7590	2.28103	5.23560	600.04	28652.1
192	36864	7077888	13.8564	5.7690	2.28330	5.20833	603.19	28952.9
193	37249	7189057	13.8924	5.7790	2.28556	5.18135	606.33	29255.3
194	37636	7301384	13.9284	5.7890	2.28780	5.15464	609.47	29559.2
195	38025	7414875	13.9642	5.7989	2.29003	5.12821	612.61	29864.8
196	38416	7529536	14.0000	5.8088	2.29226	5.10204	615.75	30171.9
197	38809	7645373	14.0357	5.8186	2.29447	5.07614	618.89	30480.5
198	39204	7762392	14.0712	5.8285	2.29667	5.05051	622.04	30790.7
199	39601	7880599	14.1067	5.8383	2.29885	5.02513	625.18	31102.6

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FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
200	40000	8000000	14.1421	5.8480	2.30103	5.00000	628.32	31415.9
201	40401	8120601	14.1774	5.8578	2.30320	4.97512	631.46	31730.9
202	40804	8242408	14.2127	5.8675	2.30535	4.95050	634.60	32047.4
203	41209	8365427	14.2478	5.8771	2.30750	4.92611	637.74	32365.5
204	41616	8489664	14.2829	5.8868	2.30963	4.90196	640.88	32685.1
205	42025	8615125	14.3178	5.8964	2.31175	4.87805	644.03	33006.4
206	42436	8741816	14.3527	5.9059	2.31387	4.85437	647.17	33329.2
207	42849	8869743	14.3875	5.9155	2.31597	4.83092	650.31	33653.5
208	43264	8998912	14.4222	5.9250	2.31806	4.80769	653.45	33979.5
209	43681	9129329	14.4568	5.9345	2.32015	4.78469	656.59	34307.0
210	44100	9261000	14.4914	5.9439	2.32222	4.76190	659.73	34636.1
211	44521	9393931	14.5258	5.9533	2.32428	4.73934	662.88	34966.7
212	44944	9528128	14.5602	5.9627	2.32634	4.71698	666.02	35298.9
213	45369	9663597	14.5945	5.9721	2.32838	4.69484	669.16	35632.7
214	45796	9800344	14.6287	5.9814	2.33041	4.67290	672.30	35968.1
215	46225	9938375	14.6629	5.9907	2.33244	4.65116	675.44	36305.0
216	46656	10077696	14.6969	6.0000	2.33445	4.62963	678.58	36643.5
217	47089	10218313	14.7309	6.0092	2.33646	4.60829	681.73	36983.6
218	47524	10360232	14.7648	6.0185	2.33846	4.58716	684.87	37325.3
219	47961	10503459	14.7986	6.0277	2.34044	4.56621	688.01	37668.5
220	48400	10648000	14.8324	6.0368	2.34242	4.54545	691.15	38013.3
221	48841	10793861	14.8661	6.0459	2.34439	4.52489	694.29	38359.6
222	49284	10941048	14.8997	6.0550	2.34635	4.50450	697.43	38707.6
223	49729	11089567	14.9332	6.0641	2.34830	4.48430	700.58	39057.1
224	50176	11239424	14.9666	6.0732	2.35025	4.46429	703.72	39408.1
225	50625	11390625	15.0000	6.0822	2.35218	4.44444	706.86	39760.8
226	51076	11543176	15.0333	6.0912	2.35411	4.42478	710.00	40115.0
227	51529	11697083	15.0665	6.1002	2.35603	4.40529	713.14	40470.8
228	51984	11852352	15.0997	6.1091	2.35793	4.38596	716.28	40828.1
229	52441	12008989	15.1327	6.1180	2.35984	4.36681	719.42	41187.1
230	52900	12167000	15.1658	6.1269	2.36173	4.34783	722.57	41547.6
231	53361	12326391	15.1987	6.1358	2.36361	4.32900	725.71	41909.6
232	53824	12487168	15.2315	6.1446	2.36549	4.31034	728.85	42273.3
233	54289	12649337	15.2643	6.1534	2.36736	4.29185	731.99	42638.5
234	54756	12812904	15.2971	6.1622	2.36922	4.27350	735.13	43005.3
235	55225	12977875	15.3297	6.1710	2.37107	4.25532	738.27	43373.6
236	55696	13144256	15.3623	6.1797	2.37291	4.23729	741.42	43743.5
237	56169	13312053	15.3948	6.1885	2.37475	4.21941	744.56	44115.0
238	56644	13481272	15.4272	6.1972	2.37658	4.20168	747.70	44488.1
239	57121	13651919	15.4596	6.2058	2.37840	4.18410	750.84	44862.7
240	57600	13824000	15.4919	6.2145	2.38021	4.16667	753.98	45238.9
241	58081	13997521	15.5242	6.2231	2.38202	4.14938	757.12	45616.7
242	58564	14172488	15.5563	6.2317	2.38382	4.13223	760.27	45996.1
243	59049	14348907	15.5885	6.2403	2.38561	4.11523	763.41	46377.0
244	59536	14526784	15.6205	6.2488	2.38739	4.09836	766.55	46759.5
245	60025	14706125	15.6525	6.2573	2.38917	4.08163	769.69	47143.5
246	60516	14886936	15.6844	6.2658	2.39094	4.06504	772.83	47529.2
247	61009	15069223	15.7162	6.2743	2.39270	4.04858	775.97	47916.4
248	61504	15252992	15.7480	6.2828	2.39445	4.03226	779.12	48305.1
249	62001	15438249	15.7797	6.2912	2.39620	4.01606	782.26	48695.5

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	Area
250	62500	15625000	15.8114	6.2996	2.39794	4.00000	785.40	49087.4
251	63001	15813251	15.8430	6.3080	2.39967	3.98406	788.54	49480.9
252	63504	16003008	15.8745	6.3164	2.40140	3.96825	791.68	49875.9
253	64009	16194277	15.9060	6.3247	2.40312	3.95257	794.82	50272.6
254	64516	16387064	15.9374	6.3330	2.40483	3.93701	797.96	50670.7
255	65025	16581375	15.9687	6.3413	2.40654	3.92157	801.11	51070.5
256	65536	16777216	16.0000	6.3496	2.40824	3.90625	804.25	51471.9
257	66049	16974593	16.0312	6.3579	2.40993	3.89105	807.39	51874.8
258	66564	17173512	16.0624	6.3661	2.41162	3.87597	810.53	52279.2
259	67081	17373979	16.0935	6.3743	2.41330	3.86100	813.67	52685.3
260	67600	17576000	16.1245	6.3825	2.41497	3.84615	816.81	53092.9
261	68121	17779581	16.1555	6.3907	2.41664	3.83142	819.96	53502.1
262	68644	17984728	16.1864	6.3988	2.41830	3.81679	823.10	53912.9
263	69169	18191447	16.2173	6.4070	2.41996	3.80228	826.24	54325.2
264	69696	18399744	16.2481	6.4151	2.42160	3.78788	829.38	54739.1
265	70225	18609625	16.2788	6.4232	2.42325	3.77358	832.52	55154.6
266	70756	18821096	16.3095	6.4312	2.42488	3.75940	835.66	55571.6
267	71289	19034163	16.3401	6.4393	2.42651	3.74532	838.81	55990.2
268	71824	19248832	16.3707	6.4473	2.42813	3.73134	841.95	56410.4
269	72361	19465109	16.4012	6.4553	2.42975	3.71747	845.09	56832.2
270	72900	19683000	16.4317	6.4633	2.43136	3.70370	848.23	57255.5
271	73441	19902511	16.4621	6.4713	2.43297	3.69004	851.37	57680.4
272	73984	20123648	16.4924	6.4792	2.43457	3.67647	854.51	58106.9
273	74529	20346417	16.5227	6.4872	2.43616	3.66300	857.65	58534.9
274	75076	20570824	16.5529	6.4951	2.43775	3.64964	860.80	58964.6
275	75625	20796875	16.5831	6.5030	2.43933	3.63636	863.94	59395.7
276	76176	21024576	16.6132	6.5108	2.44091	3.62319	867.08	59828.5
277	76729	21253933	16.6433	6.5187	2.44248	3.61011	870.22	60262.8
278	77284	21484952	16.6733	6.5265	2.44404	3.59712	873.36	60698.7
279	77841	21717639	16.7033	6.5343	2.44560	3.58423	876.50	61136.2
280	78400	21952000	16.7332	6.5421	2.44716	3.57143	879.65	61575.2
281	78961	22188041	16.7631	6.5499	2.44871	3.55872	882.79	62015.8
282	79524	22425768	16.7929	6.5577	2.45025	3.54610	885.93	62458.0
283	80089	22665187	16.8226	6.5654	2.45179	3.53357	889.07	62901.8
284	80656	22906304	16.8523	6.5731	2.45332	3.52113	892.21	63347.1
285	81225	23149125	16.8819	6.5808	2.45484	3.50877	895.35	63794.0
286	81796	23393656	16.9115	6.5885	2.45637	3.49650	898.50	64242.4
287	82369	23639903	16.9411	6.5962	2.45788	3.48432	901.64	64692.5
288	82944	23887872	16.9706	6.6039	2.45939	3.47222	904.78	65144.1
289	83521	24137569	17.0000	6.6115	2.46090	3.46021	907.92	65597.2
290	84100	24389000	17.0294	6.6191	2.46240	3.44828	911.06	66052.0
291	84681	24642171	17.0587	6.6267	2.46389	3.43643	914.20	66508.3
292	85264	24897088	17.0880	6.6343	2.46538	3.42466	917.35	66966.2
293	85849	25153757	17.1172	6.6419	2.46687	3.41297	920.49	67425.6
294	86436	25412184	17.1464	6.6494	2.46835	3.40136	923.63	67886.7
295	87025	25672375	17.1756	6.6569	2.46982	3.38983	926.77	68349.3
296	87616	25934336	17.2047	6.6644	2.47129	3.37838	929.91	68813.4
297	88209	26198073	17.2337	6.6719	2.47276	3.36700	933.05	69279.2
298	88804	26463592	17.2627	6.6794	2.47422	3.35570	936.19	69746.5
299	89401	26730899	17.2916	6.6869	2.47567	3.34448	939.34	70215.4

300
349

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	Area
300	90000	27000000	17.3205	6.6943	2.47712	3.33333	942.48	70685.8
301	90601	27270901	17.3494	6.7018	2.47857	3.32226	945.62	71157.9
302	91204	27543608	17.3781	6.7092	2.48001	3.31126	948.76	71631.5
303	91809	27818127	17.4069	6.7166	2.48144	3.30033	951.90	72106.6
304	92416	28094464	17.4356	6.7240	2.48287	3.28947	955.04	72583.4
305	93025	28372625	17.4642	6.7313	2.48430	3.27869	958.19	73061.7
306	93636	28652616	17.4929	6.7387	2.48572	3.26797	961.33	73541.5
307	94249	28934443	17.5214	6.7460	2.48714	3.25733	964.47	74023.0
308	94864	29218112	17.5499	6.7533	2.48855	3.24675	967.61	74506.0
309	95481	29503629	17.5784	6.7606	2.48996	3.23625	970.75	74990.6
310	96100	29791000	17.6068	6.7679	2.49136	3.22581	973.89	75476.8
311	96721	30080231	17.6352	6.7752	2.49276	3.21543	977.04	75964.5
312	97344	30371328	17.6635	6.7824	2.49415	3.20513	980.18	76453.8
313	97969	30664297	17.6918	6.7897	2.49554	3.19489	983.32	76944.7
314	98596	30959144	17.7200	6.7969	2.49693	3.18471	986.46	77437.1
315	99225	31255875	17.7482	6.8041	2.49831	3.17460	989.60	77931.1
316	99856	31554496	17.7764	6.8113	2.49969	3.16456	992.74	78426.7
317	100489	31855013	17.8045	6.8185	2.50106	3.15457	995.88	78923.9
318	101124	32157432	17.8326	6.8256	2.50243	3.14465	999.03	79422.6
319	101761	32461759	17.8606	6.8328	2.50379	3.13480	1002.2	79922.9
320	102400	32768000	17.8885	6.8399	2.50515	3.12500	1005.3	80424.8
321	103041	33076161	17.9165	6.8470	2.50651	3.11526	1008.5	80928.2
322	103684	33386248	17.9444	6.8541	2.50786	3.10559	1011.6	81433.2
323	104329	33698267	17.9722	6.8612	2.50920	3.09598	1014.7	81939.8
324	104976	34012224	18.0000	6.8683	2.51055	3.08642	1017.9	82448.0
325	105625	34328125	18.0278	6.8753	2.51188	3.07692	1021.0	82957.7
326	106276	34645976	18.0555	6.8824	2.51322	3.06749	1024.2	83469.0
327	106929	34965783	18.0831	6.8894	2.51455	3.05810	1027.3	83981.8
328	107584	35287552	18.1108	6.8964	2.51587	3.04878	1030.4	84496.3
329	108241	35611289	18.1384	6.9034	2.51720	3.03951	1033.6	85012.3
330	108900	35937000	18.1659	6.9104	2.51851	3.03030	1036.7	85529.9
331	109561	36264691	18.1934	6.9174	2.51983	3.02115	1039.9	86049.0
332	110224	36594368	18.2209	6.9244	2.52114	3.01205	1043.0	86569.7
333	110889	36926037	18.2483	6.9313	2.52244	3.00300	1046.2	87092.0
334	111556	37259704	18.2757	6.9382	2.52375	2.99401	1049.3	87615.9
335	112225	37595375	18.3030	6.9451	2.52504	2.98507	1052.4	88141.3
336	112896	37933056	18.3303	6.9521	2.52634	2.97619	1055.6	88668.3
337	113569	38272753	18.3576	6.9589	2.52763	2.96736	1058.7	89196.9
338	114244	38614472	18.3848	6.9658	2.52892	2.95858	1061.9	89727.0
339	114921	38958219	18.4120	6.9727	2.53020	2.94985	1065.0	90258.7
340	115600	39304000	18.4391	6.9795	2.53148	2.94118	1068.1	90792.0
341	116281	39651821	18.4662	6.9864	2.53275	2.93255	1071.3	91326.9
342	116964	40001688	18.4932	6.9932	2.53403	2.92398	1074.4	91863.3
343	117649	40353607	18.5203	7.0000	2.53529	2.91545	1077.6	92401.3
344	118336	40707584	18.5472	7.0068	2.53656	2.90698	1080.7	92940.9
345	119025	41063625	18.5742	7.0136	2.53782	2.89855	1083.8	93482.0
346	119716	41421736	18.6011	7.0203	2.53908	2.89017	1087.0	94024.7
347	120409	41781923	18.6279	7.0271	2.54033	2.88184	1090.1	94569.0
348	121104	42144192	18.6548	7.0338	2.54158	2.87356	1093.3	95114.9
349	121801	42508549	18.6815	7.0406	2.54283	2.86533	1096.4	95662.3

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
350	122500	42875000	18.7083	7.0473	2.54407	2.85714	1099.6	96211.3
351	123201	43243551	18.7350	7.0540	2.54531	2.84900	1102.7	96761.8
352	123904	43614208	18.7617	7.0607	2.54654	2.84091	1105.8	97314.0
353	124609	43986977	18.7883	7.0674	2.54777	2.83286	1109.0	97867.7
354	125316	44361864	18.8149	7.0740	2.54900	2.82486	1112.1	98423.0
355	126025	44738875	18.8414	7.0807	2.55023	2.81690	1115.3	98979.8
356	126736	45118016	18.8680	7.0873	2.55145	2.80899	1118.4	99538.2
357	127449	45499293	18.8944	7.0940	2.55267	2.80112	1121.5	100098
358	128164	45882712	18.9209	7.1006	2.55388	2.79330	1124.7	100660
359	128881	46268279	18.9473	7.1072	2.55509	2.78552	1127.8	101223
360	129600	46656000	18.9737	7.1138	2.55630	2.77778	1131.0	101788
361	130321	47045881	19.0000	7.1204	2.55751	2.77008	1134.1	102354
362	131044	47437928	19.0263	7.1269	2.55871	2.76243	1137.3	102922
363	131769	47832147	19.0526	7.1335	2.55991	2.75482	1140.4	103491
364	132496	48228544	19.0788	7.1400	2.56110	2.74725	1143.5	104062
365	133225	48627125	19.1050	7.1466	2.56229	2.73973	1146.7	104635
366	133956	49027896	19.1311	7.1531	2.56348	2.73224	1149.8	105209
367	134689	49430863	19.1572	7.1596	2.56467	2.72480	1153.0	105785
368	135424	49836032	19.1833	7.1661	2.56585	2.71739	1156.1	106362
369	136161	50243409	19.2094	7.1726	2.56703	2.71003	1159.2	106941
370	136900	50653000	19.2354	7.1791	2.56820	2.70270	1162.4	107521
371	137641	51064811	19.2614	7.1855	2.56937	2.69542	1165.5	108103
372	138384	51478848	19.2873	7.1920	2.57054	2.68817	1168.7	108687
373	139129	51895117	19.3132	7.1984	2.57171	2.68097	1171.8	109272
374	139876	52313624	19.3391	7.2048	2.57287	2.67380	1175.0	109858
375	140625	52734375	19.3649	7.2112	2.57403	2.66676	1178.1	110447
376	141376	53157376	19.3907	7.2177	2.57519	2.65957	1181.2	111036
377	142129	53582633	19.4165	7.2240	2.57634	2.65252	1184.4	111628
378	142884	54010152	19.4422	7.2304	2.57749	2.64550	1187.5	112221
379	143641	54439939	19.4679	7.2368	2.57864	2.63852	1190.7	112815
380	144400	54872000	19.4936	7.2432	2.57978	2.63158	1193.8	113411
381	145161	55306341	19.5192	7.2495	2.58093	2.62467	1196.9	114009
382	145924	55742968	19.5448	7.2558	2.58206	2.61780	1200.1	114608
383	146689	56181887	19.5704	7.2622	2.58320	2.61097	1203.2	115209
384	147456	56623104	19.5959	7.2685	2.58433	2.60417	1206.4	115812
385	148225	57066625	19.6214	7.2748	2.58546	2.59740	1209.5	116416
386	148996	57512456	19.6469	7.2811	2.58659	2.59067	1212.7	117021
387	149769	57960603	19.6723	7.2874	2.58771	2.58398	1215.8	117628
388	150544	58411072	19.6977	7.2936	2.58883	2.57732	1218.9	118237
389	151321	58863869	19.7231	7.2999	2.58995	2.57069	1222.1	118847
390	152100	59319000	19.7484	7.3061	2.59106	2.56410	1225.2	119459
391	152881	59776471	19.7737	7.3124	2.59218	2.55754	1228.4	120072
392	153664	60236288	19.7990	7.3186	2.59329	2.55102	1231.5	120687
393	154449	60698457	19.8242	7.3248	2.59439	2.54453	1234.6	121304
394	155236	61162984	19.8494	7.3310	2.59550	2.53807	1237.8	121922
395	156025	61629875	19.8746	7.3372	2.59660	2.53165	1240.9	122542
396	156816	62099136	19.8997	7.3434	2.59770	2.52525	1244.1	123163
397	157609	62570773	19.9249	7.3496	2.59879	2.51889	1247.2	123786
398	158404	63044792	19.9499	7.3558	2.59988	2.51256	1250.4	124410
399	159201	63521199	19.9750	7.3619	2.60097	2.50627	1253.5	125036

400
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FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
400	160000	64000000	20.0000	7.3681	2.60206	2.50000	1256.6	125664
401	160801	64481201	20.0250	7.3742	2.60314	2.49377	1259.8	126293
402	161604	64964808	20.0499	7.3803	2.60423	2.48756	1262.9	126923
403	162409	65450827	20.0749	7.3864	2.60531	2.48139	1266.1	127556
404	163216	65939264	20.0998	7.3925	2.60638	2.47525	1269.2	128190
405	164025	66430125	20.1246	7.3986	2.60746	2.46914	1272.3	128825
406	164836	66923416	20.1494	7.4047	2.60853	2.46305	1275.5	129462
407	165649	67419143	20.1742	7.4108	2.60959	2.45700	1278.6	130100
408	166464	67917312	20.1990	7.4169	2.61066	2.45098	1281.8	130741
409	167281	68417929	20.2237	7.4229	2.61172	2.44499	1284.9	131382
410	168100	68921000	20.2485	7.4290	2.61278	2.43902	1288.1	132025
411	168921	69426531	20.2731	7.4350	2.61384	2.43309	1291.2	132670
412	169744	69934528	20.2978	7.4410	2.61490	2.42718	1294.3	133317
413	170569	70444997	20.3224	7.4470	2.61595	2.42131	1297.5	133965
414	171396	70957944	20.3470	7.4530	2.61700	2.41546	1300.6	134614
415	172225	71473375	20.3715	7.4590	2.61805	2.40964	1303.8	135265
416	173056	71991296	20.3961	7.4650	2.61909	2.40385	1306.9	135918
417	173889	72511713	20.4206	7.4710	2.62014	2.39808	1310.0	136572
418	174724	73034632	20.4450	7.4770	2.62118	2.39234	1313.2	137228
419	175561	73560059	20.4695	7.4829	2.62221	2.38663	1316.3	137885
420	176400	74088000	20.4939	7.4889	2.62325	2.38095	1319.5	138544
421	177241	74618461	20.5183	7.4948	2.62428	2.37530	1322.6	139205
422	178084	75151448	20.5426	7.5007	2.62531	2.36967	1325.8	139867
423	178929	75686967	20.5670	7.5067	2.62634	2.36407	1328.9	140531
424	179776	76225024	20.5913	7.5126	2.62737	2.35849	1332.0	141196
425	180625	76765625	20.6155	7.5185	2.62839	2.35294	1335.2	141863
426	181476	77308776	20.6398	7.5244	2.62941	2.34742	1338.3	142531
427	182329	77854483	20.6640	7.5302	2.63043	2.34192	1341.5	143201
428	183184	78402752	20.6882	7.5361	2.63144	2.33645	1344.6	143872
429	184041	78953589	20.7123	7.5420	2.63246	2.33100	1347.7	144545
430	184900	79507000	20.7364	7.5478	2.63347	2.32558	1350.9	145220
431	185761	80062991	20.7605	7.5537	2.63448	2.32019	1354.0	145896
432	186624	80621568	20.7846	7.5595	2.63548	2.31481	1357.2	146574
433	187489	81182737	20.8087	7.5654	2.63649	2.30947	1360.3	147254
434	188356	81746504	20.8327	7.5712	2.63749	2.30415	1363.5	147934
435	189225	82312875	20.8567	7.5770	2.63849	2.29885	1366.6	148617
436	190096	82881856	20.8806	7.5828	2.63949	2.29358	1369.7	149301
437	190969	83453453	20.9045	7.5886	2.64048	2.28833	1372.9	149987
438	191844	84027672	20.9284	7.5944	2.64147	2.28311	1376.0	150674
439	192721	84604519	20.9523	7.6001	2.64246	2.27790	1379.2	151363
440	193600	85184000	20.9762	7.6059	2.64345	2.27273	1382.3	152053
441	194481	85766121	21.0000	7.6117	2.64444	2.26757	1385.4	152745
442	195364	86350888	21.0238	7.6174	2.64542	2.26244	1388.6	153439
443	196249	86938307	21.0476	7.6232	2.64640	2.25734	1391.7	154134
444	197136	87528384	21.0713	7.6289	2.64738	2.25225	1394.9	154830
445	198025	88121125	21.0950	7.6346	2.64836	2.24719	1398.0	155528
446	198916	88716536	21.1187	7.6403	2.64933	2.24215	1401.2	156228
447	199809	89314623	21.1424	7.6460	2.65031	2.23714	1404.3	156930
448	200704	89915392	21.1660	7.6517	2.65128	2.23214	1407.4	157633
449	201601	90518849	21.1896	7.6574	2.65225	2.22717	1410.6	158337

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	Area
450	202500	91125000	21.2132	7.6631	2.65321	2.22222	1413.7	159043
451	203401	91733851	21.2368	7.6688	2.65418	2.21729	1416.9	159751
452	204304	92345408	21.2603	7.6744	2.65514	2.21239	1420.0	160460
453	205209	92959677	21.2838	7.6801	2.65610	2.20751	1423.1	161171
454	206116	93576664	21.3073	7.6857	2.65706	2.20264	1426.3	161883
455	207025	94196375	21.3307	7.6914	2.65801	2.19780	1429.4	162597
456	207936	94818816	21.3542	7.6970	2.65896	2.19298	1432.6	163313
457	208849	95443993	21.3776	7.7026	2.65992	2.18818	1435.7	164030
458	209764	96071912	21.4009	7.7082	2.66087	2.18341	1438.8	164748
459	210681	96702579	21.4243	7.7138	2.66181	2.17865	1442.0	165468
460	211600	97336000	21.4476	7.7194	2.66276	2.17391	1445.1	166190
461	212521	97972181	21.4709	7.7250	2.66370	2.16920	1448.3	166914
462	213444	98611128	21.4942	7.7306	2.66464	2.16450	1451.4	167639
463	214369	99252847	21.5174	7.7362	2.66558	2.15983	1454.6	168365
464	215296	99897344	21.5407	7.7418	2.66652	2.15517	1457.7	169093
465	216225	100544625	21.5639	7.7473	2.66745	2.15054	1460.8	169823
466	217156	101194696	21.5870	7.7529	2.66839	2.14592	1464.0	170554
467	218089	101847563	21.6102	7.7584	2.66932	2.14133	1467.1	171287
468	219024	102503232	21.6333	7.7639	2.67025	2.13675	1470.3	172021
469	219961	103161709	21.6564	7.7695	2.67117	2.13220	1473.4	172757
470	220900	103823000	21.6795	7.7750	2.67210	2.12766	1476.5	173494
471	221841	104487111	21.7025	7.7805	2.67302	2.12314	1479.7	174234
472	222784	105154048	21.7256	7.7860	2.67394	2.11864	1482.8	174974
473	223729	105823817	21.7486	7.7915	2.67486	2.11416	1486.0	175716
474	224676	106496424	21.7715	7.7970	2.67578	2.10970	1489.1	176460
475	225625	107171875	21.7945	7.8025	2.67669	2.10526	1492.3	177205
476	226576	107850176	21.8174	7.8079	2.67761	2.10084	1495.4	177952
477	227529	108531333	21.8403	7.8134	2.67852	2.09644	1498.5	178701
478	228484	109215352	21.8632	7.8188	2.67943	2.09205	1501.7	179451
479	229441	109902239	21.8861	7.8243	2.68034	2.08768	1504.8	180203
480	230400	110592000	21.9089	7.8297	2.68124	2.08333	1508.0	180956
481	231361	111284641	21.9317	7.8352	2.68215	2.07900	1511.1	181711
482	232324	111980168	21.9545	7.8406	2.68305	2.07469	1514.2	182467
483	233289	112678587	21.9773	7.8460	2.68395	2.07039	1517.4	183225
484	234256	113379904	22.0000	7.8514	2.68485	2.06612	1520.5	183984
485	235225	114084125	22.0227	7.8568	2.68574	2.06186	1523.7	184745
486	236196	114791256	22.0454	7.8622	2.68664	2.05761	1526.8	185508
487	237169	115501303	22.0681	7.8676	2.68753	2.05339	1530.0	186272
488	238144	116214272	22.0907	7.8730	2.68842	2.04918	1533.1	187038
489	239121	116930169	22.1133	7.8784	2.68931	2.04499	1536.2	187805
490	240100	117649000	22.1359	7.8837	2.69020	2.04082	1539.4	188574
491	241081	118370771	22.1585	7.8891	2.69108	2.03666	1542.5	189345
492	242064	119095488	22.1811	7.8944	2.69197	2.03252	1545.7	190117
493	243049	119823157	22.2036	7.8998	2.69285	2.02840	1548.8	190890
494	244036	120553784	22.2261	7.9051	2.69373	2.02429	1551.9	191665
495	245025	121287375	22.2486	7.9105	2.69461	2.02020	1555.1	192442
496	246016	122023936	22.2711	7.9158	2.69548	2.01613	1558.2	193221
497	247009	122763473	22.2935	7.9211	2.69636	2.01207	1561.4	194000
498	248004	123505992	22.3159	7.9264	2.69723	2.00803	1564.5	194782
499	249001	124251499	22.3383	7.9317	2.69810	2.00401	1567.7	195565

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
500	250000	125000000	22.3607	7.9370	2.69897	2.00000	1570.8	196350
501	251001	125751501	22.3830	7.9423	2.69984	1.99601	1573.9	197136
502	252004	126506008	22.4054	7.9476	2.70070	1.99203	1577.1	197923
503	253009	127263527	22.4277	7.9528	2.70157	1.98807	1580.2	198713
504	254016	128024064	22.4499	7.9581	2.70243	1.98413	1583.4	199504
505	255025	128787625	22.4722	7.9634	2.70329	1.98020	1586.5	200296
506	256036	129554216	22.4944	7.9686	2.70415	1.97628	1589.6	201090
507	257049	130323843	22.5167	7.9739	2.70501	1.97239	1592.8	201886
508	258064	131096512	22.5389	7.9791	2.70586	1.96850	1595.9	202683
509	259081	131872229	22.5610	7.9843	2.70672	1.96464	1599.1	203482
510	260100	132651000	22.5832	7.9896	2.70757	1.96078	1602.2	204282
511	261121	133432831	22.6053	7.9948	2.70842	1.95695	1605.4	205084
512	262144	134217728	22.6274	8.0000	2.70927	1.95312	1608.5	205887
513	263169	135005697	22.6495	8.0052	2.71012	1.94932	1611.6	206692
514	264196	135796744	22.6716	8.0104	2.71096	1.94553	1614.8	207499
515	265225	136590875	22.6936	8.0156	2.71181	1.94175	1617.9	208307
516	266256	137388096	22.7156	8.0208	2.71265	1.93798	1621.1	209117
517	267289	138188413	22.7376	8.0260	2.71349	1.93424	1624.2	209928
518	268324	138991832	22.7596	8.0311	2.71433	1.93050	1627.3	210741
519	269361	139798359	22.7816	8.0363	2.71517	1.92678	1630.5	211556
520	270400	140608000	22.8035	8.0415	2.71600	1.92308	1633.6	212372
521	271441	141420761	22.8254	8.0466	2.71684	1.91939	1636.8	213189
522	272484	142236648	22.8473	8.0517	2.71767	1.91571	1639.9	214008
523	273529	143055667	22.8692	8.0569	2.71850	1.91205	1643.1	214829
524	274576	143877824	22.8910	8.0620	2.71933	1.90840	1646.2	215651
525	275625	144703125	22.9129	8.0671	2.72016	1.90476	1649.3	216475
526	276676	145531576	22.9347	8.0723	2.72099	1.90114	1652.5	217301
527	277729	146363183	22.9565	8.0774	2.72181	1.89753	1655.6	218128
528	278784	147197952	22.9783	8.0825	2.72263	1.89394	1658.8	218956
529	279841	148035889	23.0000	8.0876	2.72346	1.89036	1661.9	219787
530	280900	148877000	23.0217	8.0927	2.72428	1.88679	1665.0	220618
531	281961	149721291	23.0434	8.0978	2.72509	1.88324	1668.2	221452
532	283024	150568768	23.0651	8.1028	2.72591	1.87970	1671.3	222287
533	284089	151419437	23.0868	8.1079	2.72673	1.87617	1674.5	223123
534	285156	152273304	23.1084	8.1130	2.72754	1.87266	1677.6	223961
535	286225	153130375	23.1301	8.1180	2.72835	1.86916	1680.8	224801
536	287296	153990656	23.1517	8.1231	2.72916	1.86567	1683.9	225642
537	288369	154854153	23.1733	8.1281	2.72997	1.86220	1687.0	226484
538	289444	155720872	23.1948	8.1332	2.73078	1.85874	1690.2	227329
539	290521	156590819	23.2164	8.1382	2.73159	1.85529	1693.3	228175
540	291600	157464000	23.2379	8.1433	2.73239	1.85185	1696.5	229022
541	292681	158340421	23.2594	8.1483	2.73320	1.84843	1699.6	229871
542	293764	159220088	23.2809	8.1533	2.73400	1.84502	1702.7	230722
543	294849	160103007	23.3024	8.1583	2.73480	1.84162	1705.9	231574
544	295936	160989184	23.3238	8.1633	2.73560	1.83824	1709.0	232428
545	297025	161878625	23.3452	8.1683	2.73640	1.83486	1712.2	233283
546	298116	162771336	23.3666	8.1733	2.73719	1.83150	1715.3	234140
547	299209	163667323	23.3880	8.1783	2.73799	1.82815	1718.5	234998
548	300304	164566592	23.4094	8.1833	2.73878	1.82482	1721.6	235858
549	301401	165469149	23.4307	8.1882	2.73957	1.82149	1724.7	236720

FUNCTIONS OF NUMBERS

550
599

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
550	302500	166375000	23.4521	8.1932	2.74036	1.81818	1727.9	237583
551	303601	167284151	23.4734	8.1982	2.74115	1.81488	1731.0	238448
552	304704	168196608	23.4947	8.2031	2.74194	1.81159	1734.2	239314
553	305809	169112377	23.5160	8.2081	2.74273	1.80832	1737.3	240182
554	306916	170031464	23.5372	8.2130	2.74351	1.80505	1740.4	241051
555	308025	170953875	23.5584	8.2180	2.74429	1.80180	1743.6	241922
556	309136	171879616	23.5797	8.2229	2.74507	1.79856	1746.7	242795
557	310249	172808693	23.6008	8.2278	2.74586	1.79533	1749.9	243669
558	311364	173741112	23.6220	8.2327	2.74663	1.79211	1753.0	244545
559	312481	174676879	23.6432	8.2377	2.74741	1.78891	1756.2	245422
560	313600	175616000	23.6643	8.2426	2.74819	1.78571	1759.3	246301
561	314721	176558481	23.6854	8.2475	2.74896	1.78253	1762.4	247181
562	315844	177504328	23.7065	8.2524	2.74974	1.77936	1765.6	248063
563	316969	178453547	23.7276	8.2573	2.75051	1.77620	1768.7	248947
564	318096	179406144	23.7487	8.2621	2.75128	1.77305	1771.9	249832
565	319225	180362125	23.7697	8.2670	2.75205	1.76991	1775.0	250719
566	320356	181321496	23.7908	8.2719	2.75282	1.76678	1778.1	251607
567	321489	182284263	23.8118	8.2768	2.75358	1.76367	1781.3	252497
568	322624	183250432	23.8328	8.2816	2.75435	1.76056	1784.4	253388
569	323761	184220009	23.8537	8.2865	2.75511	1.75747	1787.6	254281
570	324900	185193000	23.8747	8.2913	2.75587	1.75439	1790.7	255176
571	326041	186169411	23.8956	8.2962	2.75664	1.75131	1793.8	256072
572	327184	187149248	23.9165	8.3010	2.75740	1.74825	1797.0	256970
573	328329	188132517	23.9374	8.3059	2.75815	1.74520	1800.1	257869
574	329476	189119224	23.9583	8.3107	2.75891	1.74216	1803.3	258770
575	330625	190109375	23.9792	8.3155	2.75967	1.73913	1806.4	259672
576	331776	191102976	24.0000	8.3203	2.76042	1.73611	1809.6	260576
577	332929	192100033	24.0208	8.3251	2.76118	1.73310	1812.7	261482
578	334084	193100552	24.0416	8.3300	2.76193	1.73010	1815.8	262389
579	335241	194104539	24.0624	8.3348	2.76268	1.72712	1819.0	263298
580	336400	195112000	24.0832	8.3396	2.76343	1.72414	1822.1	264208
581	337561	196122941	24.1039	9.3443	2.76418	1.72117	1825.3	265120
582	338724	197137368	24.1247	8.3491	2.76492	1.71821	1828.4	266033
583	339889	198155287	24.1454	8.3539	2.76567	1.71527	1831.6	266948
584	341056	199176704	24.1661	8.3587	2.76641	1.71233	1834.7	267865
585	342225	200201625	24.1868	8.3634	2.76716	1.70940	1837.8	268783
586	343396	201230056	24.2074	8.3682	2.76790	1.70648	1841.0	269703
587	344569	202262003	24.2281	8.3730	2.76864	1.70358	1844.1	270624
588	345744	203297472	24.2487	8.3777	2.76938	1.70068	1847.3	271547
589	346921	204336469	24.2693	8.3825	2.77012	1.69779	1850.4	272471
590	348100	205379000	24.2899	8.3872	2.77085	1.69492	1853.5	273397
591	349281	206425071	24.3105	8.3919	2.77159	1.69205	1856.7	274325
592	350464	207474688	24.3311	8.3967	2.77232	1.68919	1859.8	275254
593	351649	208527857	24.3516	8.4014	2.77305	1.68634	1863.0	276184
594	352836	209584584	24.3721	8.4061	2.77379	1.68350	1866.1	277117
595	354025	210644875	24.3926	8.4108	2.77452	1.68067	1869.2	278051
596	355216	211708736	24.4131	8.4155	2.77525	1.67785	1872.4	278986
597	356409	212776173	24.4336	8.4202	2.77597	1.67504	1875.5	279923
598	357604	213847192	24.4540	8.4249	2.77670	1.67224	1878.7	280862
599	358801	214921799	24.4745	8.4296	2.77743	1.66945	1881.8	281802

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
600	360000	216000000	24.4949	8.4343	2.77815	1.66667	1885.0	282743
601	361201	217081801	24.5153	8.4390	2.77887	1.66389	1888.1	283687
602	362404	218167208	24.5357	8.4437	2.77960	1.66113	1891.2	284631
603	363609	219256227	24.5561	8.4484	2.78032	1.65837	1894.4	285578
604	364816	220348864	24.5764	8.4530	2.78104	1.65563	1897.5	286526
605	366025	221445125	24.5967	8.4577	2.78176	1.65289	1900.7	287475
606	367236	222545016	24.6171	8.4623	2.78247	1.65017	1903.8	288426
607	368449	223648543	24.6374	8.4670	2.78319	1.64745	1906.9	289379
608	369664	224755712	24.6577	8.4716	2.78390	1.64474	1910.1	290333
609	370881	225866529	24.6779	8.4763	2.78462	1.64204	1913.2	291289
610	372100	226981000	24.6982	8.4809	2.78533	1.63934	1916.4	292247
611	373321	228099131	24.7184	8.4856	2.78604	1.63666	1919.5	293206
612	374544	229220928	24.7386	8.4902	2.78675	1.63399	1922.7	294166
613	375769	230346397	24.7588	8.4948	2.78746	1.63132	1925.8	295128
614	376996	231475544	24.7790	8.4994	2.78817	1.62866	1928.9	296092
615	378225	232608375	24.7992	8.5040	2.78888	1.62602	1932.1	297057
616	379456	233744896	24.8193	8.5086	2.78958	1.62338	1935.2	298024
617	380689	234885113	24.8395	8.5132	2.79029	1.62075	1938.4	298992
618	381924	236029032	24.8596	8.5178	2.79099	1.61812	1941.5	299962
619	383161	237176659	24.8797	8.5224	2.79169	1.61551	1944.6	300934
620	384400	238328000	24.8998	8.5270	2.79239	1.61290	1947.8	301907
621	385641	239483061	24.9199	8.5316	2.79309	1.61031	1950.9	302882
622	386884	240641848	24.9399	8.5362	2.79379	1.60772	1954.1	303858
623	388129	241804367	24.9600	8.5408	2.79449	1.60514	1957.2	304836
624	389376	242970624	24.9800	8.5453	2.79518	1.60256	1960.4	305815
625	390625	244140625	25.0000	8.5499	2.79588	1.60000	1963.5	306796
626	391876	245314376	25.0200	8.5544	2.79657	1.59744	1966.6	307779
627	393129	246491883	25.0400	8.5590	2.79727	1.59490	1969.8	308763
628	394384	247673152	25.0599	8.5635	2.79796	1.59236	1972.9	309748
629	395641	248858189	25.0799	8.5681	2.79865	1.58983	1976.1	310736
630	396900	250047000	25.0998	8.5726	2.79934	1.58730	1979.2	311725
631	398161	251239591	25.1197	8.5772	2.80003	1.58479	1982.3	312715
632	399424	252435968	25.1396	8.5817	2.80072	1.58228	1985.5	313707
633	400689	253636137	25.1595	8.5862	2.80140	1.57978	1988.6	314700
634	401956	254840104	25.1794	8.5907	2.80209	1.57729	1991.8	315696
635	403225	256047875	25.1992	8.5952	2.80277	1.57480	1994.9	316692
636	404496	257259456	25.2190	8.5997	2.80346	1.57233	1998.1	317690
637	405769	258474853	25.2389	8.6043	2.80414	1.56986	2001.2	318690
638	407044	259694072	25.2587	8.6088	2.80482	1.56740	2004.3	319692
639	408321	260917119	25.2784	8.6132	2.80550	1.56495	2007.5	320695
640	409600	262144000	25.2982	8.6177	2.80618	1.56250	2010.6	321699
641	410881	263374721	25.3180	8.6222	2.80686	1.56006	2013.8	322705
642	412164	264609288	25.3377	8.6267	2.80754	1.55763	2016.9	323713
643	413449	265847707	25.3574	8.6312	2.80821	1.55521	2020.0	324722
644	414736	267089984	25.3772	8.6357	2.80889	1.55280	2023.2	325733
645	416025	268336125	25.3969	8.6401	2.80956	1.55039	2026.3	326745
646	417316	269586136	25.4165	8.6446	2.81023	1.54799	2029.5	327759
647	418609	270840023	25.4362	8.6490	2.81090	1.54560	2032.6	328775
648	419904	272097792	25.4558	8.6535	2.81158	1.54321	2035.8	329792
649	421201	273359449	25.4755	8.6579	2.81224	1.54083	2038.9	330810

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
650	422500	274625000	25.4951	8.6624	2.81291	1.53846	2042.0	331831
651	423801	275894451	25.5147	8.6668	2.81358	1.53610	2045.2	332853
652	425104	277167808	25.5343	8.6713	2.81425	1.53374	2048.3	333876
653	426409	278445077	25.5539	8.6757	2.81491	1.53139	2051.5	334901
654	427716	279726264	25.5734	8.6801	2.81558	1.52905	2054.6	335927
655	429025	281011375	25.5930	8.6845	2.81624	1.52672	2057.7	336955
656	430336	282300416	25.6125	8.6890	2.81690	1.52439	2060.9	337985
657	431649	283593393	25.6320	8.6934	2.81757	1.52207	2064.0	339016
658	432964	284890312	25.6515	8.6978	2.81823	1.51976	2067.2	340049
659	434281	286191179	25.6710	8.7022	2.81889	1.51745	2070.3	341084
660	435600	287496000	25.6905	8.7066	2.81954	1.51515	2073.5	342119
661	436921	288804781	25.7099	8.7110	2.82020	1.51286	2076.6	343157
662	438244	290117528	25.7294	8.7154	2.82086	1.51057	2079.7	344196
663	439569	291434247	25.7488	8.7198	2.82151	1.50830	2082.9	345237
664	440896	292754944	25.7682	8.7241	2.82217	1.50602	2086.0	346279
665	442225	294079625	25.7876	8.7285	2.82282	1.50376	2089.2	347323
666	443556	295408296	25.8070	8.7329	2.82347	1.50150	2092.3	348368
667	444889	296740963	25.8263	8.7373	2.82413	1.49925	2095.4	349415
668	446224	298077632	25.8457	8.7416	2.82478	1.49701	2098.6	350464
669	447561	299418309	25.8650	8.7460	2.82543	1.49477	2101.7	351514
670	448900	300763000	25.8844	8.7503	2.82607	1.49254	2104.9	352565
671	450241	302111711	25.9037	8.7547	2.82672	1.49031	2108.0	353618
672	451584	303464448	25.9230	8.7590	2.82737	1.48810	2111.2	354673
673	452929	304821217	25.9422	8.7634	2.82802	1.48588	2114.3	355730
674	454276	306182024	25.9615	8.7677	2.82866	1.48368	2117.4	356788
675	455625	307546875	25.9808	8.7721	2.82930	1.48148	2120.6	357847
676	456976	308915776	26.0000	8.7764	2.82995	1.47929	2123.7	358908
677	458329	310288733	26.0192	8.7807	2.83059	1.47710	2126.9	359971
678	459684	311665752	26.0384	8.7850	2.83123	1.47493	2130.0	361035
679	461041	313046839	26.0576	8.7893	2.83187	1.47275	2133.1	362101
680	462400	314432000	26.0768	8.7937	2.83251	1.47059	2136.3	363168
681	463761	315821241	26.0960	8.7980	2.83315	1.46843	2139.4	364237
682	465124	317214568	26.1151	8.8023	2.83378	1.46628	2142.6	365308
683	466489	318611987	26.1343	8.8066	2.83442	1.46413	2145.7	366380
684	467856	320013504	26.1534	8.8109	2.83506	1.46199	2148.8	367453
685	469225	321419125	26.1725	8.8152	2.83569	1.45985	2152.0	368528
686	470596	322828856	26.1916	8.8194	2.83632	1.45773	2155.1	369605
687	471969	324242703	26.2107	8.8237	2.83696	1.45560	2158.3	370684
688	473344	325660672	26.2298	8.8280	2.83759	1.45349	2161.4	371764
689	474721	327082769	26.2488	8.8323	2.83822	1.45138	2164.6	372845
690	476100	328509000	26.2679	8.8366	2.83885	1.44928	2167.7	373928
691	477481	329939371	26.2869	8.8408	2.83948	1.44718	2170.8	375013
692	478864	331373888	26.3059	8.8451	2.84011	1.44509	2174.0	376099
693	480249	332812557	26.3249	8.8493	2.84073	1.44300	2177.1	377187
694	481636	334255384	26.3439	8.8536	2.84136	1.44092	2180.3	378276
695	483025	335702375	26.3629	8.8578	2.84198	1.43885	2183.4	379367
696	484416	337153536	26.3818	8.8621	2.84261	1.43678	2186.5	380459
697	485809	338608873	26.4008	8.8663	2.84323	1.43472	2189.7	381553
698	487204	340068392	26.4197	8.8706	2.84386	1.43266	2192.8	382649
699	488601	341532099	26.4386	8.8748	2.84448	1.43062	2196.0	383746

700
749

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
700	490000	343000000	26.4575	8.8790	2.84510	1.42857	2199.1	384845
701	491401	344472101	26.4764	8.8833	2.84572	1.42653	2202.3	385945
702	492804	345948408	26.4953	8.8875	2.84634	1.42450	2205.4	387047
703	494209	347428927	26.5141	8.8917	2.84696	1.42248	2208.5	388151
704	495616	348913664	26.5330	8.8959	2.84757	1.42045	2211.7	389256
705	497025	350402625	26.5518	8.9001	2.84819	1.41844	2214.8	390363
706	498436	351895816	26.5707	8.9043	2.84880	1.41643	2218.0	391471
707	499849	353393243	26.5895	8.9085	2.84942	1.41443	2221.1	392580
708	501264	354894912	26.6083	8.9127	2.85003	1.41243	2224.2	393692
709	502681	356400829	26.6271	8.9169	2.85065	1.41044	2227.4	394805
710	504100	357911000	26.6458	8.9211	2.85126	1.40845	2230.5	395919
711	505521	359425431	26.6646	8.9253	2.85187	1.40647	2233.7	397035
712	506944	360944128	26.6833	8.9295	2.85248	1.40449	2236.8	398153
713	508369	362467097	26.7021	8.9337	2.85309	1.40252	2240.0	399272
714	509796	363994344	26.7208	8.9378	2.85370	1.40056	2243.1	400393
715	511225	365525875	26.7395	8.9420	2.85431	1.39860	2246.2	401515
716	512656	367061696	26.7582	8.9462	2.85491	1.39665	2249.4	402639
717	514089	368601813	26.7769	8.9503	2.85552	1.39470	2252.5	403765
718	515524	370146232	26.7955	8.9545	2.85612	1.39276	2255.7	404892
719	516961	371694959	26.8142	8.9587	2.85673	1.39082	2258.8	406020
720	518400	373248000	26.8328	8.9628	2.85733	1.38889	2261.9	407150
721	519841	374805361	26.8514	8.9670	2.85794	1.38696	2265.1	408282
722	521284	376367048	26.8701	8.9711	2.85854	1.38504	2268.2	409415
723	522729	377933067	26.8887	8.9752	2.85914	1.38313	2271.4	410550
724	524176	379503424	26.9072	8.9794	2.85974	1.38122	2274.5	411687
725	525625	381078125	26.9258	8.9835	2.86034	1.37931	2277.7	412825
726	527076	382657176	26.9444	8.9876	2.86094	1.37741	2280.8	413965
727	528529	384240583	26.9629	8.9918	2.86153	1.37552	2283.9	415106
728	529984	385828352	26.9815	8.9959	2.86213	1.37363	2287.1	416248
729	531441	387420489	27.0000	9.0000	2.86273	1.37174	2290.2	417393
730	532900	389017000	27.0185	9.0041	2.86332	1.36986	2293.4	418539
731	534361	390617891	27.0370	9.0082	2.86392	1.36799	2296.5	419686
732	535824	392223168	27.0555	9.0123	2.86451	1.36612	2299.6	420835
733	537289	393832837	27.0740	9.0164	2.86510	1.36426	2302.8	421986
734	538756	395446904	27.0924	9.0205	2.86570	1.36240	2305.9	423138
735	540225	397065375	27.1109	9.0246	2.86629	1.36054	2309.1	424293
736	541696	398688256	27.1293	9.0287	2.86688	1.35870	2312.2	425447
737	543169	400315553	27.1477	9.0328	2.86747	1.35685	2315.4	426604
738	544644	401947272	27.1662	9.0369	2.86806	1.35501	2318.5	427762
739	546121	403583419	27.1846	9.0410	2.86864	1.35318	2321.6	428922
740	547600	405224000	27.2029	9.0450	2.86923	1.35135	2324.8	430084
741	549081	406869021	27.2213	9.0491	2.86982	1.34953	2327.9	431247
742	550564	408518488	27.2397	9.0532	2.87040	1.34771	2331.1	432412
743	552049	410172407	27.2580	9.0572	2.87099	1.34590	2334.2	433578
744	553536	411830784	27.2764	9.0613	2.87157	1.34409	2337.3	434746
745	555025	413493625	27.2947	9.0654	2.87216	1.34228	2340.5	435916
746	556516	415160936	27.3130	9.0694	2.87274	1.34048	2343.6	437087
747	558009	416832723	27.3313	9.0735	2.87332	1.33869	2346.8	438259
748	559504	418508992	27.3496	9.0775	2.87390	1.33690	2349.9	439433
749	561001	420189749	27.3679	9.0816	2.87448	1.33511	2353.1	440609

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
750	562500	421875000	27.3861	9.0856	2.87506	1.33333	2356.2	441786
751	564001	423564751	27.4044	9.0896	2.87564	1.33156	2359.3	442965
752	565504	425259008	27.4226	9.0937	2.87622	1.32979	2362.5	444146
753	567009	426957777	27.4408	9.0977	2.87680	1.32802	2365.6	445328
754	568516	428661064	27.4591	9.1017	2.87737	1.32626	2368.8	446511
755	570025	430368875	27.4773	9.1057	2.87795	1.32450	2371.9	447697
756	571536	432081216	27.4955	9.1098	2.87852	1.32275	2375.0	448883
757	573049	433798093	27.5136	9.1138	2.87910	1.32100	2378.2	450072
758	574564	435519512	27.5318	9.1178	2.87967	1.31926	2381.3	451262
759	576081	437245479	27.5500	9.1218	2.88024	1.31752	2384.5	452453
760	577600	438976000	27.5681	9.1258	2.88081	1.31579	2387.6	453646
761	579121	440711081	27.5862	9.1298	2.88138	1.31406	2390.8	454841
762	580644	442450728	27.6043	9.1338	2.88196	1.31234	2393.9	456037
763	582169	444194947	27.6225	9.1378	2.88252	1.31062	2397.0	457234
764	583696	445943744	27.6405	9.1418	2.88309	1.30890	2400.2	458434
765	585225	447697125	27.6586	9.1458	2.88366	1.30719	2403.3	459635
766	586756	449455096	27.6767	9.1498	2.88423	1.30548	2406.5	460837
767	588289	451217663	27.6948	9.1537	2.88480	1.30378	2409.6	462041
768	589824	452984832	27.7128	9.1577	2.88536	1.30208	2412.7	463247
769	591361	454756609	27.7308	9.1617	2.88593	1.30039	2415.9	464454
770	592900	456533000	27.7489	9.1657	2.88649	1.29870	2419.0	465663
771	594441	458314011	27.7669	9.1696	2.88705	1.29702	2422.2	466873
772	595984	460099648	27.7849	9.1736	2.88762	1.29534	2425.3	468085
773	597529	461889917	27.8029	9.1775	2.88818	1.29366	2428.5	469298
774	599076	463684824	27.8209	9.1815	2.88874	1.29199	2431.6	470513
775	600625	465484375	27.8388	9.1855	2.88930	1.29032	2434.7	471730
776	602176	467288576	27.8568	9.1894	2.88986	1.28866	2437.9	472948
777	603729	469097433	27.8747	9.1933	2.89042	1.28700	2441.0	474168
778	605284	470910952	27.8927	9.1973	2.89098	1.28535	2444.2	475389
779	606841	472729139	27.9106	9.2012	2.89154	1.28370	2447.3	476612
780	608400	474552000	27.9285	9.2052	2.89209	1.28205	2450.4	477836
781	609961	476379541	27.9464	9.2091	2.89265	1.28041	2453.6	479062
782	611524	478211768	27.9643	9.2130	2.89321	1.27877	2456.7	480290
783	613089	480048687	27.9821	9.2170	2.89376	1.27714	2459.9	481519
784	614656	481890304	28.0000	9.2209	2.89432	1.27551	2463.0	482750
785	616225	483736625	28.0179	9.2248	2.89487	1.27389	2466.2	483982
786	617796	485587656	28.0357	9.2287	2.89542	1.27226	2469.3	485216
787	619369	487443403	28.0535	9.2326	2.89597	1.27065	2472.4	486451
788	620944	489303872	28.0713	9.2365	2.89653	1.26904	2475.6	487688
789	622521	491169069	28.0891	9.2404	2.89708	1.26743	2478.7	488927
790	624100	493039000	28.1069	9.2443	2.89763	1.26582	2481.9	490167
791	625681	494913671	28.1247	9.2482	2.89818	1.26422	2485.0	491409
792	627264	496793088	28.1425	9.2521	2.89873	1.26263	2488.1	492652
793	628849	498677257	28.1603	9.2560	2.89927	1.26103	2491.3	493897
794	630436	500566184	28.1780	9.2599	2.89982	1.25945	2494.4	495143
795	632025	502459875	28.1957	9.2638	2.90037	1.25786	2497.6	496391
796	633616	504358336	28.2135	9.2677	2.90091	1.25628	2500.7	497641
797	635209	506261573	28.2312	9.2716	2.90146	1.25471	2503.8	498892
798	636804	508169592	28.2489	9.2754	2.90200	1.25313	2507.0	500145
799	638401	510082399	28.2666	9.2793	2.90255	1.25156	2510.1	501399

800
849

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
800	640000	512000000	28.2843	9.2832	2.90309	1.25000	2513.3	502655
801	641601	513922401	28.3019	9.2870	2.90363	1.24844	2516.4	503912
802	643204	515849608	28.3196	9.2909	2.90417	1.24688	2519.6	505171
803	644809	517781627	28.3373	9.2948	2.90472	1.24533	2522.7	506432
804	646416	519718464	28.3549	9.2986	2.90526	1.24378	2525.8	507694
805	648025	521660125	28.3725	9.3025	2.90580	1.24224	2529.0	508958
806	649636	523606616	28.3901	9.3063	2.90634	1.24069	2532.1	510223
807	651249	525557943	28.4077	9.3102	2.90687	1.23916	2535.3	511490
808	652864	527514112	28.4253	9.3140	2.90741	1.23762	2538.4	512758
809	654481	529475129	28.4429	9.3179	2.90795	1.23609	2541.5	514028
810	656100	531441000	28.4605	9.3217	2.90849	1.23457	2544.7	515300
811	657721	533411731	28.4781	9.3255	2.90902	1.23305	2547.8	516573
812	659344	535387328	28.4956	9.3294	2.90956	1.23153	2551.0	517848
813	660969	537367797	28.5132	9.3332	2.91009	1.23001	2554.1	519124
814	662596	539353144	28.5307	9.3370	2.91062	1.22850	2557.3	520402
815	664225	541343375	28.5482	9.3408	2.91116	1.22699	2560.4	521681
816	665856	543338496	28.5657	9.3447	2.91169	1.22549	2563.5	522962
817	667489	545338513	28.5832	9.3485	2.91222	1.22399	2566.7	524245
818	669124	547343432	28.6007	9.3523	2.91275	1.22249	2569.8	525529
819	670761	549353259	28.6182	9.3561	2.91328	1.22100	2573.0	526814
820	672400	551368000	28.6356	9.3599	2.91381	1.21951	2576.1	528102
821	674041	553387661	28.6531	9.3637	2.91434	1.21803	2579.2	529391
822	675684	555412248	28.6705	9.3675	2.91487	1.21655	2582.4	530681
823	677329	557441767	28.6880	9.3713	2.91540	1.21507	2585.5	531973
824	678976	559476224	28.7054	9.3751	2.91593	1.21359	2588.7	533267
825	680625	561515625	28.7228	9.3789	2.91645	1.21212	2591.8	534562
826	682276	563559976	28.7402	9.3827	2.91698	1.21065	2595.0	535858
827	683929	565609283	28.7576	9.3865	2.91751	1.20919	2598.1	537157
828	685584	567663552	28.7750	9.3902	2.91803	1.20773	2601.2	538456
829	687241	569722789	28.7924	9.3940	2.91855	1.20627	2604.4	539758
830	688900	571787000	28.8097	9.3978	2.91908	1.20482	2607.5	541061
831	690561	573856191	28.8271	9.4016	2.91960	1.20337	2610.7	542365
832	692224	575930368	28.8444	9.4053	2.92012	1.20192	2613.8	543671
833	693889	578009537	28.8617	9.4091	2.92065	1.20048	2616.9	544979
834	695556	580093704	28.8791	9.4129	2.92117	1.19904	2620.1	546288
835	697225	582182875	28.8964	9.4166	2.92169	1.19760	2623.2	547599
836	698896	584277056	28.9137	9.4204	2.92221	1.19617	2626.4	548912
837	700569	586376253	28.9310	9.4241	2.92273	1.19474	2629.5	550226
838	702244	588480472	28.9482	9.4279	2.92324	1.19332	2632.7	551541
839	703921	590589719	28.9655	9.4316	2.92376	1.19190	2635.8	552858
840	705600	592704000	28.9828	9.4354	2.92428	1.19048	2638.9	554177
841	707281	594823321	29.0000	9.4391	2.92480	1.18906	2642.1	555497
842	708964	596947688	29.0172	9.4429	2.92531	1.18765	2645.2	556819
843	710649	599077107	29.0345	9.4466	2.92583	1.18624	2648.4	558142
844	712336	601211584	29.0517	9.4503	2.92634	1.18483	2651.5	559467
845	714025	603351125	29.0689	9.4541	2.92686	1.18343	2654.6	560794
846	715716	605495736	29.0861	9.4578	2.92737	1.18203	2657.8	562122
847	717409	607645423	29.1033	9.4615	2.92788	1.18064	2660.9	563452
848	719104	609800192	29.1204	9.4652	2.92840	1.17925	2664.1	564783
849	720801	611960049	29.1376	9.4690	2.92891	1.17786	2667.2	566116

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter	
							Circum.	Area
850	722500	614125000	29.1548	9.4727	2.92942	1.17647	2670.4	567450
851	724201	616295051	29.1719	9.4764	2.92993	1.17509	2673.5	568786
852	725904	618470208	29.1890	9.4801	2.93044	1.17371	2676.6	570124
853	727609	620650477	29.2062	9.4838	2.93095	1.17233	2679.8	571463
854	729316	622835864	29.2233	9.4875	2.93146	1.17096	2682.9	572803
855	731025	625026375	29.2404	9.4912	2.93197	1.16959	2686.1	574146
856	732736	627222016	29.2575	9.4949	2.93247	1.16822	2689.2	575490
857	734449	629422793	29.2746	9.4986	2.93298	1.16686	2692.3	576835
858	736164	631628712	29.2916	9.5023	2.93349	1.16550	2695.5	578182
859	737881	633839779	29.3087	9.5060	2.93399	1.16414	2698.6	579530
860	739600	636056000	29.3258	9.5097	2.93450	1.16279	2701.8	580880
861	741321	638277381	29.3428	9.5134	2.93500	1.16144	2704.9	582232
862	743044	640503928	29.3598	9.5171	2.93551	1.16009	2708.1	583585
863	744769	642735647	29.3769	9.5207	2.93601	1.15875	2711.2	584940
864	746496	644972544	29.3939	9.5244	2.93651	1.15741	2714.3	586297
865	748225	647214625	29.4109	9.5281	2.93702	1.15607	2717.5	587655
866	749956	649461896	29.4279	9.5317	2.93752	1.15473	2720.6	589014
867	751689	651714363	29.4449	9.5354	2.93802	1.15340	2723.8	590375
868	753424	653972032	29.4618	9.5391	2.93852	1.15207	2726.9	591738
869	755161	656234909	29.4788	9.5427	2.93902	1.15075	2730.0	583102
870	756900	658503000	29.4958	9.5464	2.93952	1.14943	2733.2	594468
871	758641	660776311	29.5127	9.5501	2.94002	1.14811	2736.3	595835
872	760384	663054848	29.5296	9.5537	2.94052	1.14679	2739.5	597204
873	762129	665338617	29.5466	9.5574	2.94101	1.14548	2742.6	598575
874	763876	667627624	29.5635	9.5610	2.94151	1.14416	2745.8	599947
875	765625	669921875	29.5804	9.5647	2.94201	1.14286	2748.9	601320
876	767376	672221376	29.5973	9.5683	2.94250	1.14155	2752.0	602696
877	769129	674526133	29.6142	9.5719	2.94300	1.14025	2755.2	604073
878	770884	676836152	29.6311	9.5756	2.94349	1.13895	2758.3	605451
879	772641	679151439	29.6479	9.5792	2.94399	1.13766	2761.5	606831
880	774400	681472000	29.6648	9.5828	2.94448	1.13636	2764.6	608212
881	776161	683797841	29.6816	9.5865	2.94498	1.13507	2767.7	609595
882	777924	686128968	29.6985	9.5901	2.94547	1.13379	2770.9	610980
883	779689	688465387	29.7153	9.5937	2.94596	1.13250	2774.0	612366
884	781456	690807104	29.7321	9.5973	2.94645	1.13122	2777.2	613754
885	783225	693154125	29.7489	9.6010	2.94694	1.12994	2780.3	615143
886	784996	695506456	29.7658	9.6046	2.94743	1.12867	2783.5	616534
887	786769	697864103	29.7825	9.6082	2.94792	1.12740	2786.6	617927
888	788544	700227072	29.7993	9.6118	2.94841	1.12613	2789.7	619321
889	790321	702595369	29.8161	9.6154	2.94890	1.12486	2792.9	620717
890	792100	704969000	29.8329	9.6190	2.94939	1.12360	2796.0	622114
891	793881	707347971	29.8496	9.6226	2.94988	1.12233	2799.2	623513
892	795664	709732288	29.8664	9.6262	2.95036	1.12108	2802.3	624913
893	797449	712121957	29.8831	9.6298	2.95085	1.11982	2805.4	626315
894	799236	714516984	29.8998	9.6334	2.95134	1.11857	2808.6	627718
895	801025	716917375	29.9166	9.6370	2.95182	1.11732	2811.7	629124
896	802816	719323136	29.9333	9.6406	2.95231	1.11607	2814.9	630530
897	804609	721734273	29.9500	9.6442	2.95279	1.11483	2818.0	631938
898	806404	724150792	29.9666	9.6477	2.95328	1.11359	2821.2	633348
899	808201	726572699	29.9833	9.6513	2.95376	1.11235	2824.3	634760

900
949

FUNCTIONS OF NUMBERS

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	No. = Diameter Area
900	810000	729000000	30.0000	9.6549	2.95424	1.11111	2827.4	636173
901	811801	731432701	30.0167	9.6585	2.95472	1.10988	2830.6	637587
902	813604	733870808	30.0333	9.6620	2.95521	1.10865	2833.7	639003
903	815409	736314327	30.0500	9.6656	2.95569	1.10742	2836.9	640421
904	817216	738763264	30.0666	9.6692	2.95617	1.10619	2840.0	641840
905	819025	741217625	30.0832	9.6727	2.95665	1.10497	2843.1	643261
906	820836	743677416	30.0998	9.6763	2.95713	1.10375	2846.3	644683
907	822649	746142643	30.1164	9.6799	2.95761	1.10254	2849.4	646107
908	824464	748613312	30.1330	9.6834	2.95809	1.10132	2852.6	647533
909	826281	751089429	30.1496	9.6870	2.95856	1.10011	2855.7	648960
910	828100	753571000	30.1662	9.6905	2.95904	1.09890	2858.8	650388
911	829921	756058031	30.1828	9.6941	2.95952	1.09769	2862.0	651818
912	831744	758550528	30.1993	9.6976	2.95999	1.09649	2865.1	653250
913	833569	761048497	30.2159	9.7012	2.96047	1.09529	2868.3	654684
914	835396	763551944	30.2324	9.7047	2.96095	1.09409	2871.4	656118
915	837225	766060875	30.2490	9.7082	2.96142	1.09290	2874.6	657555
916	839056	768575296	30.2655	9.7118	2.96190	1.09170	2877.7	658993
917	840889	771095213	30.2820	9.7153	2.96237	1.09051	2880.8	660433
918	842724	773620632	30.2985	9.7188	2.96284	1.08932	2884.0	661874
919	844561	776151559	30.3150	9.7224	2.96332	1.08814	2887.1	663317
920	846400	778688000	30.3315	9.7259	2.96379	1.08696	2890.3	664761
921	848241	781229961	30.3480	9.7294	2.96426	1.08578	2893.4	666207
922	850084	783777448	30.3645	9.7329	2.96473	1.08460	2896.5	667654
923	851929	786330467	30.3809	9.7364	2.96520	1.08342	2899.7	669103
924	853776	788889024	30.3974	9.7400	2.96567	1.08225	2902.8	670554
925	855625	791453125	30.4138	9.7435	2.96614	1.08108	2906.0	672006
926	857476	794022776	30.4302	9.7470	2.96661	1.07991	2909.1	673460
927	859329	796597983	30.4467	9.7505	2.96708	1.07875	2912.3	674915
928	861184	799178752	30.4631	9.7540	2.96755	1.07759	2915.4	676372
929	863041	801765089	30.4795	9.7575	2.96802	1.07643	2918.5	677831
930	864900	804357000	30.4959	9.7610	2.96848	1.07527	2921.7	679291
931	866761	806954491	30.5123	9.7645	2.96895	1.07411	2924.8	680752
932	868624	809557568	30.5287	9.7680	2.96942	1.07296	2928.0	682216
933	870489	812166237	30.5450	9.7715	2.96988	1.07181	2931.1	683680
934	872356	814780504	30.5614	9.7750	2.97035	1.07066	2934.2	685147
935	874225	817400375	30.5778	9.7785	2.97081	1.06952	2937.4	686615
936	876096	820025856	30.5941	9.7819	2.97128	1.06838	2940.5	688084
937	877969	822656953	30.6105	9.7854	2.97174	1.06724	2943.7	689555
938	879844	825293672	30.6268	9.7889	2.97220	1.06610	2946.8	691028
939	881721	827936019	30.6431	9.7924	2.97267	1.06496	2950.0	692502
940	883600	830584000	30.6594	9.7959	2.97313	1.06383	2953.1	693978
941	885481	833237621	30.6757	9.7993	2.97359	1.06270	2956.2	695455
942	887364	835896888	30.6920	9.8028	2.97405	1.06157	2959.4	696934
943	889249	838561807	30.7083	9.8063	2.97451	1.06045	2962.5	698415
944	891136	841232384	30.7246	9.8097	2.97497	1.05932	2965.7	699897
945	893025	843908625	30.7409	9.8132	2.97543	1.05820	2968.8	701380
946	894916	846590536	30.7571	9.8167	2.97589	1.05708	2971.9	702865
947	896809	849278123	30.7734	9.8201	2.97635	1.05597	2975.1	704352
948	898704	851971392	30.7896	9.8236	2.97681	1.05485	2978.2	705840
949	900601	854670349	30.8058	9.8270	2.97727	1.05374	2981.4	707330

FUNCTIONS OF NUMBERS

950
999

No.	Square	Cube	Square Root	Cube Root	Logarithm	1000 × Reciprocal	No. = Diameter Circum.	Area
950	902500	857375000	30.8221	9.8305	2.97772	1.05263	2984.5	708822
951	904401	860085351	30.8383	9.8339	2.97818	1.05152	2987.7	710315
952	906304	862801408	30.8545	9.8374	2.97864	1.05042	2990.8	711809
953	908209	865523177	30.8707	9.8408	2.97909	1.04932	2993.9	713306
954	910116	868250664	30.8869	9.8443	2.97955	1.04822	2997.1	714803
955	912025	870983875	30.9031	9.8477	2.98000	1.04712	3000.2	716303
956	913936	873722816	30.9192	9.8511	2.98046	1.04603	3003.4	717804
957	915849	876467493	30.9354	9.8546	2.98091	1.04493	3006.5	719306
958	917764	879217912	30.9516	9.8580	2.98137	1.04384	3009.6	720810
959	919681	881974079	30.9677	9.8614	2.98182	1.04275	3012.8	722316
960	921600	884736000	30.9839	9.8648	2.98227	1.04167	3015.9	723823
961	923521	887503681	31.0000	9.8683	2.98272	1.04058	3019.1	725332
962	925444	890277128	31.0161	9.8717	2.98318	1.03950	3022.2	726842
963	927369	893056347	31.0322	9.8751	2.98363	1.03842	3025.4	728354
964	929296	895841344	31.0483	9.8785	2.98408	1.03734	3028.5	729867
965	931225	898632125	31.0644	9.8819	2.98453	1.03627	3031.6	731382
966	933156	901428696	31.0805	9.8854	2.98498	1.03520	3034.8	732899
967	935089	904231063	31.0966	9.8888	2.98543	1.03413	3037.9	734417
968	937024	907039232	31.1127	9.8922	2.98588	1.03306	3041.1	735937
969	938961	909853209	31.1288	9.8956	2.98632	1.03199	3044.2	737458
970	940900	912673000	31.1448	9.8990	2.98677	1.03093	3047.3	738981
971	942841	915498611	31.1609	9.9024	2.98722	1.02987	3050.5	740506
972	944784	918330048	31.1769	9.9058	2.98767	1.02881	3053.6	742032
973	946729	921167317	31.1929	9.9092	2.98811	1.02775	3056.8	743559
974	948676	924010424	31.2090	9.9126	2.98856	1.02669	3059.9	745088
975	950625	926859375	31.2250	9.9160	2.98900	1.02564	3063.1	746619
976	952576	929714176	31.2410	9.9194	2.98945	1.02459	3066.2	748151
977	954529	932574833	31.2570	9.9227	2.98989	1.02354	3069.3	749685
978	956484	935441352	31.2730	9.9261	2.99034	1.02249	3072.5	751221
979	958441	938313739	31.2890	9.9295	2.99078	1.02145	3075.6	752758
980	960400	941192000	31.3050	9.9329	2.99123	1.02041	3078.8	754296
981	962361	944076141	31.3209	9.9363	2.99167	1.01937	3081.9	755837
982	964324	946966168	31.3369	9.9396	2.99211	1.01833	3085.0	757378
983	966289	949862087	31.3528	9.9430	2.99255	1.01729	3088.2	758922
984	968256	952763904	31.3688	9.9464	2.99300	1.01626	3091.3	760466
985	970225	955671625	31.3847	9.9497	2.99344	1.01523	3094.5	762013
986	972196	958585256	31.4006	9.9531	2.99388	1.01420	3097.6	763561
987	974169	961504803	31.4166	9.9565	2.99432	1.01317	3100.8	765111
988	976144	964430272	31.4325	9.9598	2.99476	1.01215	3103.9	766662
989	978121	967361669	31.4484	9.9632	2.99520	1.01112	3107.0	768214
990	980100	970299000	31.4643	9.9666	2.99564	1.01010	3110.2	769769
991	982081	973242271	31.4802	9.9699	2.99607	1.00908	3113.3	771325
992	984064	976191488	31.4960	9.9733	2.99651	1.00806	3116.5	772882
993	986049	979146657	31.5119	9.9766	2.99695	1.00705	3119.6	774441
994	988036	982107784	31.5278	9.9800	2.99739	1.00604	3122.7	776002
995	990025	985074875	31.5436	9.9833	2.99782	1.00503	3125.9	777564
996	992016	988047936	31.5595	9.9866	2.99826	1.00402	3129.0	779128
997	994009	991026973	31.5753	9.9900	2.99870	1.00301	3132.2	780693
998	996004	994011992	31.5911	9.9933	2.99913	1.00200	3135.3	782260
999	998001	997002999	31.6070	9.9967	2.99957	1.00100	3138.5	783828

WIRE AND SHEET METAL GAGES

IN DECIMALS OF AN INCH

Name of Gage	United States Standard Gage*		The United States Steel Wire Gage	American or Brown & Sharpe Wire Gage	New Birmingham Standard Sheet & Hoop Gage	British Imperial or English Legal Standard Wire Gage	Birmingham or Stubs Iron Wire Gage	Name of Gage
Principal Use	Uncoated Steel Sheets and Light Plates		Steel Wire except Music Wire	Non-Ferrous Sheets and Wire	Iron and Steel Sheets and Hoops	Wire	Strips, Bands, Hoops and Wire	Principal Use
Gage No.	Weight Oz. per Sq. Ft.	Approx. Thickness Inches	Thickness, Inches					Gage No.
7/0's			.4900		.6666	.500		7/0's
6/0's			.4615	.5800	.625	.464		6/0's
5/0's			.4305	.5165	.5883	.432	.500	5/0's
4/0's			.3938	.4600	.5416	.400	.454	4/0's
3/0's			.3625	.4096	.500	.372	.425	3/0's
2/0's			.3310	.3648	.4452	.348	.380	2/0's
0			.3065	.3249	.3964	.324	.340	0
1			.2830	.2893	.3532	.300	.300	1
2			.2625	.2576	.3147	.276	.284	2
3	160	.2391	.2437	.2294	.2804	.252	.259	3
4	150	.2242	.2253	.2043	.250	.232	.238	4
5	140	.2092	.2070	.1819	.2225	.212	.220	5
6	130	.1943	.1920	.1620	.1981	.192	.203	6
7	120	.1793	.1770	.1443	.1764	.176	.180	7
8	110	.1644	.1620	.1285	.1570	.160	.165	8
9	100	.1495	.1483	.1144	.1398	.144	.148	9
10	90	.1345	.1350	.1019	.1250	.128	.134	10
11	80	.1196	.1205	.0907	.1113	.116	.120	11
12	70	.1046	.1055	.0808	.0991	.104	.109	12
13	60	.0897	.0915	.0720	.0882	.092	.095	13
14	50	.0747	.0800	.0641	.0785	.080	.083	14
15	45	.0673	.0720	.0571	.0699	.072	.072	15
16	40	.0598	.0625	.0508	.0625	.064	.065	16
17	36	.0538	.0540	.0453	.0556	.056	.058	17
18	32	.0478	.0475	.0403	.0495	.048	.049	18
19	28	.0418	.0410	.0359	.0440	.040	.042	19
20	24	.0359	.0348	.0320	.0392	.036	.035	20
21	22	.0329	.0318	.0285	.0349	.032	.032	21
22	20	.0299	.0286	.0253	.0313	.028	.028	22
23	18	.0269	.0258	.0226	.0278	.024	.025	23
24	16	.0239	.0230	.0201	.0248	.022	.022	24
25	14	.0209	.0204	.0179	.0220	.020	.020	25
26	12	.0179	.0181	.0159	.0196	.018	.018	26
27	11	.0164	.0173	.0142	.0175	.0164	.016	27
28	10	.0149	.0162	.0126	.0156	.0148	.014	28
29	9	.0135	.0150	.0113	.0139	.0136	.013	29
30	8	.0120	.0140	.0100	.0123	.0124	.012	30
31	7	.0105	.0132	.0089	.0110	.0116	.010	31
32	6.5	.0097	.0128	.0080	.0098	.0108	.009	32
33	6	.0090	.0118	.0071	.0087	.0100	.008	33
34	5.5	.0082	.0104	.0063	.0077	.0092	.007	34
35	5	.0075	.0095	.0056	.0069	.0084	.005	35
36	4.5	.0067	.0090	.0050	.0061	.0076	.004	36
37	4.25	.0064	.0085	.0045	.0054	.0068		37
38	4	.0060	.0080	.0040	.0048	.0060		38
39			.0075	.0035	.0043	.0052		39
40			.0070	.0031	.0039	.0048		40

* U. S. Standard Gage is officially a weight gage, in oz. per sq. ft. as tabulated. The Approx. Thickness shown is the "Manufacturers' Standard" of the American Iron and Steel Institute, based on steel as weighing 501.81 lbs. per cu. ft. (489.6 true weight plus 2.5 percent for average over-run in area and thickness). The A.I.S.I. standard nomenclature for flat rolled carbon steel is as follows:

Widths, Inches	Thicknesses, Inch							
	0.2500 and thicker	0.2499 to 0.2031	0.2030 to 0.1875	0.1874 to 0.0568	0.0567 to 0.0344	0.0343 to 0.0255	0.0254 to 0.0142	0.0141 and thinner
To 3½ incl.	Bar	Bar	Strip	Strip	Strip	Strip	Sheet	Sheet
Over 3½ to 6 incl.	Bar	Bar	Strip	Strip	Strip	Sheet	Sheet	Sheet
" 6 to 12 "	Plate	Strip	Strip	Strip	Sheet	Sheet	Sheet	Sheet
" 12 to 32 "	Plate	Sheet	Sheet	Sheet	Sheet	Sheet	Sheet	Black Plate
" 32 to 48 "	Plate	Sheet	Sheet	Sheet	Sheet	Sheet	Sheet	Sheet
" 48	Plate	Plate	Plate	Sheet	Sheet	Sheet	Sheet	——

WEIGHTS AND MEASURES

UNITED STATES SYSTEM

LINEAR MEASURE

Inches	Feet	Yards	Rods	Furlongs	Miles
1.0 =	.08333 =	.02778 =	.0050505 =	.00012626 =	.00001578
12.0 =	1.0 =	.33333 =	.0606061 =	.00151515 =	.00018939
36.0 =	3.0 =	1.0 =	.1818182 =	.00454545 =	.00056818
198.0 =	16.5 =	5.5 =	1.0 =	.025 =	.003125
7920.0 =	660.0 =	220.0 =	40.0 =	1.0 =	.125
63360.0 =	5280.0 =	1760.0 =	320.0 =	8.0 =	1.0

SQUARE AND LAND MEASURE

Sq. Inches	Square Feet	Square Yards	Sq. Rods	Acres	Sq. Miles
1.0 =	.006944 =	.000772			
144.0 =	1.0 =	.111111			
1296.0 =	9.0 =	1.0 =	.03306 =	.000207	
39204.0 =	272.25 =	30.25 =	1.0 =	.00625 =	.0000098
	43560.0 =	4840.0 =	160.0 =	1.0 =	.0015625
		3097600.0 =	102400.0 =	640.0 =	1.0

AVOIRDUPOIS WEIGHTS

Grains	Drams	Ounces	Pounds	Tons
1.0 =	.03657 =	.002286 =	.000143 =	.0000000714
27.34375 =	1.0 =	.0625 =	.003906 =	.00000195
437.5 =	16.0 =	1.0 =	.0625 =	.00003125
7000.0 =	256.0 =	16.0 =	1.0 =	.0005
14000000.0 =	512000.0 =	32000.0 =	2000.0 =	1.0

DRY MEASURE

Pints	Quarts	Pecks	Cubic Feet	Bushels
1.0 =	.5 =	.0625 =	.01945 =	.01563
2.0 =	1.0 =	.125 =	.03891 =	.03125
16.0 =	8.0 =	1.0 =	.31112 =	.25
51.42627 =	25.71314 =	3.21414 =	1.0 =	.80354
64.0 =	32.0 =	4.0 =	1.2445 =	1.0

LIQUID MEASURE

Gills	Pints	Quarts	U. S. Gallons	Cubic Feet
1.0 =	.25 =	.125 =	.03125 =	.00418
4.0 =	1.0 =	.5 =	.125 =	.01671
8.0 =	2.0 =	1.0 =	.250 =	.03342
32.0 =	8.0 =	4.0 =	1.0 =	.1337
			7.48052 =	1.0

METRIC SYSTEM

UNITS

Length—Meter : Mass—Gram : Capacity—Liter

for pure water at 4°C. (39.2°F.)
1 cubic decimeter or 1 liter = 1 kilogram

1000 Milli {*meters* (mm), *grams* (mg), *liters* (ml)} = 100 Centi {*meters* (cm), *grams* (cg), *liters* (cl)} = 10 Deci {*meters* (dm), *grams* (dg), *liters* (dl)} = 1 {meter, gram, liter}

1000 {meters, grams, liters} = 100 Deka {*meters* (dkm), *grams* (dkg), *liters* (dkl)} = 10 Hecto {*meters* (hm), *grams* (hg), *liters* (hl)} = 1 Kilo {*meter* (km), *gram* (kg), *liter* (kl)}

1 Metric Ton	=	1000 Kilograms
100 Square Meters	=	1 Are
100 Ares	=	1 Hectare
100 Hectares	=	1 Square Kilometer

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ENGINEERING CONVERSION FACTORS

Multiply	by	to obtain
acres	.404687	hectares
"	4.04687×10^{-3}	square kilometers
ares	1076.39	square feet
board feet	144 sq. in. × 1 in.	cubic inches
" "	.0833	cubic feet
centimeters	3.28083×10^{-2}	feet
"	.3937	inches
cubic centimeters	3.53145×10^{-5}	cubic feet
" "	6.102×10^{-2}	cubic inches
cubic feet	2.8317×10^{4}	cubic centimeters
" "	2.8317×10^{-2}	cubic meters
" "	6.22905	gallons, British Imperial
" "	28.3170	liters
" "	2.38095×10^{-2}	tons, British Shipping
" "	.025	tons, U. S. Shipping
cubic inches	16.38716	cubic centimeters
cubic meters	35.3145	cubic feet
" "	1.30794	cubic yards
cubic yards	.764559	cubic meters
degrees, angular	.0174533	radians
degrees, Fahrenheit (less 32 F.)	.5556	degrees, Centigrade
" Centigrade	1.8	degrees, Fahrenheit (less 32 F.)
foot pounds	.13826	kilogram meters
feet	30.4801	centimeters
"	.304801	meters
"	304.801	millimeters
"	1.64468×10^{-4}	miles, nautical
gallons, British Imperial	.160538	cubic feet
" " "	1.20091	gallons, U. S.
" " "	4.54596	liters
gallons, U. S.	.832702	gallons, British Imperial
" "	.13368	cubic feet
" "	231.	cubic inches
" "	3.78543	liters
grams, metric	2.20462×10^{-3}	pounds, avoirdupois
hectares	2.47104	acres
"	1.076387×10^{5}	square feet
"	3.86101×10^{-3}	square miles
horse-power, metric	.98632	horse-power, U. S.
horse-power, U. S.	1.01387	horse-power, metric
inches	2.54001	centimeters
"	2.54001×10^{-2}	meters
"	25.4001	millimeters
kilograms	2.20462	pounds
"	9.84206×10^{-4}	long tons
"	1.10231×10^{-3}	short tons
kilogram meters	7.233	foot pounds
kilograms per meter	.671972	pounds per foot
kilograms per square centimeter	14.2234	pounds per square inch
kilograms per square meter	.204817	pounds per square foot
" " " "	9.14362×10^{-5}	long tons per square foot
kilograms per square millimeter	1422.34	pounds per square inch
" " " "	.634973	long tons per square inch
kilograms per cubic meter	6.24283×10^{-2}	pounds per cubic foot
kilometers	.62137	miles, statute
"	.53959	miles, nautical

ENGINEERING CONVERSION FACTORS

Multiply	by	to obtain
liters	.219975	gallons, British Imperial
"	.26417	gallons, U. S.
"	3.53145×10^{-2}	cubic feet
meters	3.28083	feet
"	39.37	inches
"	1.09361	yards
miles, statute	1.60935	kilometers
" "	.8684	miles, nautical
miles, nautical	6080.204	feet
" "	1.85325	kilometers
" "	1.1516	miles, statute
millimeters	3.28083×10^{-3}	feet
"	3.937×10^{-2}	inches
pounds, avoirdupois	453.592	grams, metric
" "	.453592	kilograms
" "	4.464×10^{-4}	tons, long
" "	4.53592×10^{-4}	tons, metric
pounds per foot	1.48816	kilograms per meter
pounds per square foot	4.88241	kilograms per square meter
pounds per square inch	7.031×10^{-2}	kilograms per square centimeter
" " " "	7.031×10^{-4}	kilograms per square millimeter
pounds per cubic foot	16.0184	kilograms per cubic meter
radians	57.29578	degrees, angular
square centimeters	.1550	square inches
square feet	9.29034×10^{-4}	ares
" "	9.29034×10^{-6}	hectares
" "	.0929034	square meters
square inches	6.45163	square centimeters
" "	645.163	square millimeters
square kilometers	247.104	acres
" "	.3861	square miles
square meters	10.7639	square feet
" "	1.19599	square yards
square miles	259.0	hectares
" "	2.590	square kilometers
square millimeters	1.550×10^{-3}	square inches
square yards	.83613	square meters
tons, long	1016.05	kilograms
" "	2240.	pounds
" "	1.01605	tons, metric
" "	1.120	tons, short
tons, long, per square foot	1.09366×10^{-4}	kilograms per square meter
tons, long, per square inch	1.57494	kilograms per square millimeter
tons, metric	2204.62	pounds
" "	.98421	tons, long
" "	1.10231	tons, short
tons, short	907.185	kilograms
" "	.892857	tons, long
" "	.907185	tons, metric
tons, British Shipping	42.00	cubic feet
" " "	.952381	tons, U. S. Shipping
tons, U. S. Shipping	40.00	cubic feet
" " "	1.050	tons, British Shipping
yards	.914402	meters

DECIMALS OF A FOOT
FOR EACH 32ND OF AN INCH

Inch	0″	1″	2″	3″	4″	5″
0	0	.0833	.1667	.2500	.3333	.4167
1/32	.0026	.0859	.1693	.2526	.3359	.4193
1/16	.0052	.0885	.1719	.2552	.3385	.4219
3/32	.0078	.0911	.1745	.2578	.3411	.4245
1/8	.0104	.0938	.1771	.2604	.3438	.4271
5/32	.0130	.0964	.1797	.2630	.3464	.4297
3/16	.0156	.0990	.1823	.2656	.3490	.4323
7/32	.0182	.1016	.1849	.2682	.3516	.4349
1/4	.0208	.1042	.1875	.2708	.3542	.4375
9/32	.0234	.1068	.1901	.2734	.3568	.4401
5/16	.0260	.1094	.1927	.2760	.3594	.4427
11/32	.0286	.1120	.1953	.2786	.3620	.4453
3/8	.0313	.1146	.1979	.2812	.3646	.4479
13/32	.0339	.1172	.2005	.2839	.3672	.4505
7/16	.0365	.1198	.2031	.2865	.3698	.4531
15/32	.0391	.1224	2057	.2891	.3724	.4557
1/2	.0417	.1250	.2083	.2917	.3750	.4583
17/32	.0443	.1276	.2109	.2943	.3776	.4609
9/16	.0469	.1302	.2135	.2969	.3802	.4635
19/32	.0495	.1328	.2161	.2995	.3828	.4661
5/8	.0521	.1354	.2188	.3021	.3854	.4688
21/32	.0547	.1380	.2214	.3047	.3880	.4714
11/16	.0573	.1406	.2240	.3073	.3906	.4740
23/32	.0599	.1432	.2266	.3099	.3932	.4766
3/4	.0625	.1458	.2292	.3125	.3958	.4792
25/32	.0651	.1484	.2318	.3151	.3984	.4818
13/16	.0677	.1510	.2344	.3177	.4010	.4844
27/32	.0703	.1536	.2370	.3203	.4036	.4870
7/8	.0729	.1563	.2396	.3229	.4063	.4896
29/32	.0755	.1589	.2422	.3255	.4089	.4922
15/16	.0781	.1615	.2448	.3281	.4115	.4948
31/32	.0807	.1641	.2474	.3307	.4141	.4974

DECIMALS OF A FOOT
FOR EACH 32ND OF AN INCH

Inch	6″	7″	8″	9″	10″	11″
0	.5000	.5833	.6667	.7500	.8333	.9167
1/32	.5026	.5859	.6693	.7526	.8359	.9193
1/16	.5052	.5885	.6719	.7552	.8385	.9219
3/32	.5078	.5911	.6745	.7578	.8411	.9245
1/8	.5104	.5938	.6771	.7604	.8438	.9271
5/32	.5130	.5964	.6797	.7630	.8464	.9297
3/16	.5156	.5990	.6823	.7656	.8490	.9323
7/32	.5182	.6016	.6849	.7682	.8516	.9349
1/4	.5208	.6042	.6875	.7708	.8542	.9375
9/32	.5234	.6068	.6901	.7734	.8568	.9401
5/16	.5260	.6094	.6927	.7760	.8594	.9427
11/32	.5286	.6120	.6953	.7786	.8620	.9453
3/8	.5313	.6146	.6979	.7813	.8646	.9479
13/32	.5339	.6172	.7005	.7839	.8672	.9505
7/16	.5365	.6198	.7031	.7865	.8698	.9531
15/32	.5391	.6224	.7057	.7891	.8724	.9557
1/2	.5417	.6250	.7083	.7917	.8750	.9583
17/32	.5443	.6276	.7109	.7943	.8776	.9609
9/16	.5469	.6302	.7135	.7969	.8802	.9635
19/32	.5495	.6328	.7161	.7995	.8828	.9661
5/8	.5521	.6354	.7188	.8021	.8854	.9688
21/32	.5547	.6380	.7214	.8047	.8880	.9714
11/16	.5573	.6406	.7240	.8073	.8906	.9740
23/32	.5599	.6432	.7266	.8099	.8932	.9766
3/4	.5625	.6458	.7292	.8125	.8958	.9792
25/32	.5651	.6484	7318	.8151	.8984	.9818
13/16	.5677	.6510	.7344	.8177	.9010	.9844
27/32	.5703	.6536	.7370	.8203	.9036	.9870
7/8	.5729	.6563	.7396	.8229	.9063	.9896
29/32	.5755	.6589	.7422	.8255	.9089	.9922
15/16	.5781	.6615	.7448	.8281	.9115	.9948
31/32	.5807	.6641	.7474	.8307	.9141	.9974

DECIMALS OF AN INCH FOR EACH 64TH OF AN INCH

WITH MILLIMETER EQUIVALENTS

Fraction	1/64ths	Decimal	Millimeters (approx.)	Fraction	1/64ths	Decimal	Millimeters (approx.)
----	1	.015625	0.397	----	33	.515625	13.097
1/32	2	.03125	0.794	17/32	34	.53125	13.494
----	3	.046875	1.191	----	35	.546875	13.891
1/16	4	.0625	1.588	9/16	36	.5625	14.288
----	5	.078125	1.984	----	37	.578125	14.684
3/32	6	.09375	2.381	19/32	38	.59375	15.081
----	7	.109375	2.778	----	39	.609375	15.478
1/8	8	.125	3.175	5/8	40	.625	15.875
----	9	.140625	3.572	----	41	.640625	16.272
5/32	10	.15625	3.969	21/32	42	.65625	16.669
----	11	.171875	4.366	----	43	.671875	17.066
3/16	12	.1875	4.763	11/16	44	.6875	17.463
----	13	.203125	5.159	----	45	.703125	17.859
7/32	14	.21875	5.556	23/32	46	.71875	18.256
----	15	.234375	5.953	----	47	.734375	18.653
1/4	16	.250	6.350	3/4	48	.750	19.050
----	17	.265625	6.747	----	49	.765625	19.447
9/32	18	.28125	7.144	25/32	50	.78125	19.844
----	19	.296875	7.541	----	51	.796875	20.241
5/16	20	.3125	7.938	13/16	52	.8125	20.638
----	21	.328125	8.334	----	53	.828125	21.034
11/32	22	.34375	8.731	27/32	54	.84375	21.431
----	23	.359375	9.128	----	55	.859375	21.828
3/8	24	.375	9.525	7/8	56	.875	22.225
----	25	.390625	9.922	----	57	.890625	22.622
13/32	26	.40625	10.319	29/32	58	.90625	23.019
----	27	.421875	10.716	----	59	.921875	23.416
7/16	28	.4375	11.113	15/16	60	.9375	23.813
----	29	.453125	11.509	----	61	.953125	24.209
15/32	30	.46875	11.906	31/32	62	.96875	24.606
----	31	.484375	12.303	----	63	.984375	25.003
1/2	32	.500	12.700	1	64	1.000	25.400

INDEX

INDEX

NOTE: The A. I. S. C. Specification and A. I. S. C. Code are herein indexed as to general Section headings. Further details of Specification and Code are not indexed.

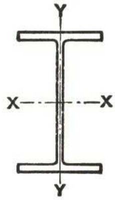
ADDENDUM

Since the Fifth Edition of the Manual was set in type, the Kaiser Steel Corporation has commenced the production of certain wide-flange shapes at its Fontana, California, plant. These shapes have the same nominal sizes as similar shapes listed in the Manual. Their actual dimensions and design properties, as shown in this leaflet, are somewhat different.

Also shown in this leaflet are the design properties and dimensions of certain light columns produced by the Kaiser Steel Corporation. It will be noted that some of these shapes are identical in dimension with the light columns tabulated on pages 26 and 27 of the Manual.

It is anticipated that the shapes covered in this addendum will be inserted in their proper location or otherwise covered by footnotes in the next edition of the Manual.

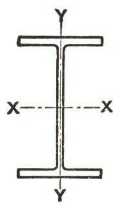
KAISER STEEL CORPORATION
WF SHAPES
PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area	Depth	Flange Width	Flange Thick-ness	Web Thick-ness	AXIS X-X I	AXIS X-X S	AXIS X-X r	AXIS Y-Y I	AXIS Y-Y S	AXIS Y-Y r
Inches	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.⁴	In.³	In.
10 x 5¾	29.1	8.55	9.875	5.935	.389	.425	131.5	26.6	3.92	11.2	3.7	1.14
	22.9	6.73	9.875	5.750	.389	.240	116.6	23.6	4.16	9.9	3.5	1.22
8 x 5¼	22.5	6.61	8.000	5.395	.352	.375	68.3	17.1	3.23	7.5	2.8	1.08
	18.5	5.44	8.000	5.250	.352	.230	62.1	15.5	3.38	6.9	2.6	1.13

All flanges have 6° taper and flange thickness is an average thickness.

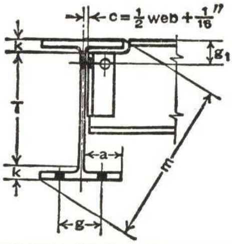
KAISER STEEL CORPORATION
LIGHT COLUMNS
PROPERTIES FOR DESIGNING



Nominal Size	Weight per Foot	Area of Sect.	Depth of Sect.	Width of Flange	Web Thick-ness	AXIS X-X I	AXIS X-X S	AXIS X-X r	AXIS Y-Y I	AXIS Y-Y S	AXIS Y-Y r
Inches	Lb.	In.²	In.	In.	In.	In.⁴	In.³	In.	In.⁴	In.³	In.
*8 x 8	34.3	10.09	8.00	8.000	.375	115.5	28.9	3.40	35.1	8.8	1.87
8 x 8	32.6	9.59	8.00	7.938	.313	112.8	28.2	3.45	34.2	8.6	1.90
6 x 6	22.5	6.62	6.00	6.063	.375	41.0	13.7	2.49	12.2	4.0	1.36
*6 x 6	20.0	5.88	6.00	5.938	.250	38.8	12.9	2.57	11.4	3.8	1.39
§5 x 5	18.9	5.56	5.00	5.000	.313	23.8	9.5	2.08	7.8	3.1	1.20
4 x 4	13.0	3.82	4.00	3.940	.253	9.9	5.0	1.64	3.3	1.7	.95

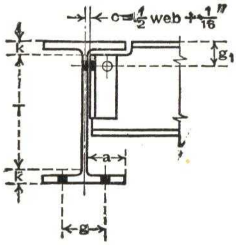
* Also rolled by United States Steel Corp. and Inland Steel Co.
§ Also rolled by United States Steel Corp. and Bethlehem Steel Co.-M.

REGULAR SERIES



KAISER STEEL CORPORATION
WF SHAPES
DIMENSIONS FOR DETAILING

Nominal Size	Weight per Foot	Depth	Flange Width	Flange Thickness	Web Thickness	Web Half Thickness	Distance a	Distance T	Distance k	Distance m	Distance g_1	Distance c	Usual Gage g
Inches	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
10 x 5¾	29.1	9⅞	5 15/16	⅜	7/16	3/16	2¾	8¼	13/16	11½	2¼	¼	2¾
	22.9	9⅞	5¾	⅜	¼	⅛	2¾	8¼	13/16	11⅜	2	3/16	2¾
8 x 5¼	22.5	8	5⅜	⅜	⅜	3/16	2½	6½	¾	9⅝	2¼	¼	2¾
	18.5	8	5¼	⅜	¼	⅛	2½	6½	¾	9⅝	2¼	3/16	2¾



KAISER STEEL CORPORATION
LIGHT COLUMNS
DIMENSIONS FOR DETAILING

Nominal Size	Weight per Foot	Depth	Flange Width	Flange Thickness	Web Thickness	Web Half Thickness	Distance a	Distance T	Distance k	Distance g_1	Distance c	Max. Flange Rivet	Usual Gage g
Inches	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
*8 x 8	34.3	8	8	7/16	⅜	3/16	3⅞	6¼	⅞	2½	¼	⅞	5½
8 x 8	32.6	8	8	7/16	5/16	3/16	3⅞	6¼	⅞	2½	¼	⅞	5½
6 x 6	22.5	6	6⅛	⅜	⅜	3/16	2⅞	4⅜	13/16	2¼	¼	⅞	3½
*6 x 6	20.0	6	6	⅜	¼	⅛	2⅞	4⅜	13/16	2¼	3/16	⅞	3½
§5 x 5	18.9	5	5	7/16	5/16	3/16	2⅜	3⅜	13/16	2¼	¼	¾	2¾
4 x 4	13.0	4	3 15/16	⅜	¼	⅛	1⅞	2½	¾	2	3/16	⅝	2¼

* Also rolled by United States Steel Corp. and Inland Steel Co.
§ Also rolled by United States Steel Corp. and Bethlehem Steel Co.-M.

Fifth Edition

ECCENTRIC LOADS ON WELD GROUPS

AND

WELDED BEAM CONNECTIONS

(MANUAL STEEL CONSTRUCTION SUPPLEMENT)

AMERICAN INSTITUTE OF STEEL CONSTRUCTION
101 PARK AVENUE
NEW YORK 17, N. Y.

FOREWORD

The material given herein is substantially in agreement with similar information which has been available for a number of years, although the manner of its presentation is quite different.

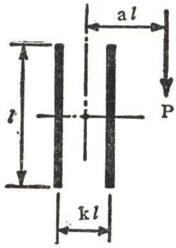
Tables of coefficients for computing the safe load on eccentrically loaded weld groups can be made to cover satisfactorily a wider range of the variables involved than would be the case if the relationship between these variables were shown graphically. Curves drawn to a scale that would permit reading coefficient values, with the degree of accuracy possible by interpolation in the tables, would be far too large for inclusion in the Manual.

The use of tables of allowable loads for beam web connections, and for unstiffened and stiffened beam seats, in lieu of charts, follows the pattern long established in the Manual for riveted fabrication. It is believed that the codification of fitting material and required welds into a relatively few combinations will afford a greater overall economy than would be the case if each connection were individually "designed" for the particular conditions of its intended use.

These tables first appeared in the Appendix of the A.I.S.C. Structural Shop Drafting Textbook, Volume 2. Pending the publication of a new Edition of the A.I.S.C. Manual this means is being taken to place them in the hands of all users of the Fifth Edition.

ECCENTRIC LOADS ON WELD GROUPS

COEFFICIENTS



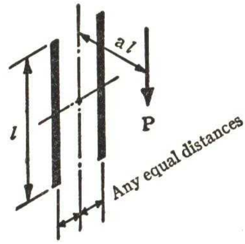
P = Permissible eccentric load in Kips.
l = Length of each weld in inches.
D = Number of sixteenths of an inch in fillet weld size.
C = Coefficients tabulated below.

$$P = CDl$$

$$\text{Required Minimum } C = \frac{P}{Dl}$$

$$\text{" \quad " } D = \frac{P}{Cl}$$

$$\text{" \quad " } l = \frac{P}{CD}$$



SPECIAL CASE

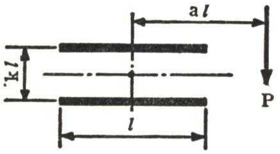
(Load not in plane of weld group.)

Use C-values given in column headed k = O.

a	k = 0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0
0.2	.768	.744	.741	.753	.773	.796	.819	.842	.862	.882	.899	.930	.955	.976	.994	1.01
0.3	.582	.570	.577	.597	.625	.655	.686	.716	.742	.768	.790	.830	.863	.890	.914	.934
0.4	.462	.455	.466	.489	.519	.552	.586	.618	.648	.677	.702	.747	.785	.817	.845	.869
0.5	.380	.377	.389	.412	.441	.475	.509	.542	.573	.603	.630	.678	.719	.754	.785	.811
0.6	.322	.320	.332	.355	.383	.415	.449	.481	.513	.543	.571	.620	.663	.700	.732	.760
0.7	.278	.278	.290	.311	.338	.369	.401	.433	.464	.493	.521	.571	.615	.653	.686	.716
0.8	.244	.246	.257	.276	.302	.331	.362	.392	.423	.452	.479	.529	.572	.611	.645	.675
0.9	.218	.220	.230	.249	.273	.300	.329	.359	.388	.416	.443	.492	.536	.574	.608	.639
1.0	.198	.199	.209	.226	.249	.274	.302	.330	.358	.386	.412	.460	.503	.541	.576	.607
1.2	.166	.167	.176	.191	.211	.234	.259	.285	.311	.336	.360	.406	.448	.486	.520	.551
1.4	.142	.144	.152	.165	.183	.204	.227	.250	.274	.298	.320	.364	.404	.440	.473	.504
1.6	.124	.126	.133	.146	.162	.181	.201	.223	.245	.266	.288	.329	.367	.402	.435	.464
1.8	.110	.112	.119	.130	.145	.162	.181	.201	.221	.242	.262	.301	.337	.375	.402	.430
2.0	.100	.101	.107	.118	.131	.147	.165	.183	.202	.221	.240	.277	.311	.343	.374	.401
2.2	.090	.092	.098	.107	.120	.134	.151	.168	.186	.204	.221	.256	.289	.320	.348	.375
2.4	.084	.085	.090	.099	.110	.124	.139	.155	.172	.189	.205	.238	.269	.299	.327	.353
2.6	.076	.078	.083	.091	.102	.115	.129	.144	.160	.176	.192	.223	.253	.284	.308	.333
2.8	.072	.073	.077	.085	.095	.107	.120	.135	.149	.164	.180	.209	.238	.265	.291	.315
3.0	.066	.068	.072	.079	.089	.100	.113	.126	.140	.155	.169	.197	.224	.251	.275	.300

ECCENTRIC LOADS ON WELD GROUPS

COEFFICIENTS



P = Permissible eccentric load in Kips.
l = Length of each weld in inches.
D = Number of sixteenths of an inch in fillet weld size.
C = Coefficients tabulated below.

$$P = CDl$$

Required Minimum $C = \frac{P}{Dl}$

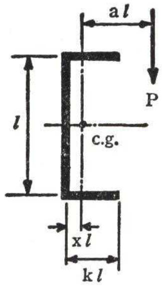
" " $D = \frac{P}{Cl}$

" " $l = \frac{P}{CD}$

a	k															
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0
0.2	.545	.553	.576	.611	.652	.698	.743	.787	.827	.866	.899	.956	1.00	1.04	1.06	1.08
0.3	.429	.436	.457	.489	.529	.573	.620	.666	.710	.752	.790	.858	.913	.958	.995	1.02
0.4	.353	.359	.378	.407	.444	.486	.530	.575	.619	.662	.702	.775	.836	.888	.931	.968
0.5	.300	.306	.323	.349	.383	.422	.463	.506	.548	.590	.630	.704	.771	.825	.872	.913
0.6	.261	.266	.281	.306	.336	.372	.411	.451	.491	.532	.571	.644	.710	.768	.818	.873
0.7	.231	.236	.250	.272	.300	.333	.369	.407	.445	.483	.521	.593	.658	.717	.769	.815
0.8	.207	.211	.224	.244	.270	.301	.335	.373	.406	.443	.479	.548	.613	.672	.724	.771
0.9	.187	.189	.203	.222	.246	.275	.306	.339	.374	.408	.443	.510	.573	.631	.683	.731
1.0	.171	.175	.186	.203	.226	.253	.282	.314	.346	.379	.412	.476	.537	.594	.646	.694
1.2	.146	.150	.159	.174	.194	.218	.244	.272	.301	.331	.360	.420	.477	.531	.582	.629
1.4	.128	.131	.139	.153	.170	.191	.215	.240	.266	.293	.320	.375	.428	.479	.528	.573
1.6	.113	.116	.123	.136	.151	.170	.192	.215	.239	.263	.288	.339	.388	.436	.482	.526
1.8	.102	.104	.111	.122	.136	.154	.173	.194	.216	.239	.262	.309	.355	.405	.444	.485
2.0	.092	.094	.101	.111	.124	.140	.158	.177	.197	.219	.240	.283	.327	.369	.410	.450
2.2	.084	.086	.092	.102	.114	.129	.145	.163	.182	.201	.221	.262	.303	.343	.382	.419
2.4	.078	.080	.085	.094	.105	.119	.134	.151	.168	.187	.205	.243	.282	.319	.356	.392
2.6	.072	.074	.079	.087	.098	.110	.125	.140	.157	.174	.192	.227	.263	.299	.334	.369
2.8	.067	.069	.074	.081	.091	.103	.117	.131	.147	.163	.180	.213	.247	.281	.315	.347
3.0	.063	.065	.069	.076	.086	.097	.109	.123	.138	.153	.169	.201	.233	.265	.297	.328

ECCENTRIC LOADS ON WELD GROUPS

COEFFICIENTS



P = Permissible eccentric load in Kips.
l = Length of weld parallel to load "P" in inches.
D = Number of sixteenths of an inch in fillet weld size.
C = Coefficients tabulated below.
xl = Distance from vertical weld to center of gravity of weld group.

$$P = CDl$$

Required Minimum $C = \frac{P}{Dl}$

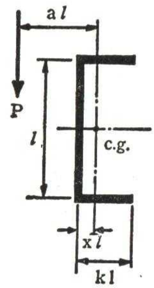
" " $D = \frac{P}{Cl}$

" " $l = \frac{P}{CD}$

a	k															
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0
0.2	.384	.516	.575	.654	.731	.810	.889	.969	1.05	1.14	1.22	1.40	1.58	1.78	1.97	2.17
0.3	.291	.422	.472	.543	.612	.680	.749	.820	.893	.966	1.04	1.20	1.37	1.54	1.72	1.91
0.4	.231	.351	.395	.460	.522	.583	.644	.708	.772	.839	.908	1.05	1.20	1.36	1.52	1.69
0.5	.190	.298	.338	.397	.453	.508	.564	.621	.680	.740	.802	.932	1.07	1.21	1.36	1.52
0.6	.161	.258	.294	.348	.399	.450	.500	.552	.605	.661	.718	.836	.963	1.09	1.24	1.38
0.7	.139	.227	.260	.310	.357	.403	.449	.497	.546	.596	.649	.759	.875	.998	1.13	1.27
0.8	.122	.202	.233	.278	.322	.364	.407	.451	.497	.543	.592	.694	.802	.917	1.04	1.17
0.9	.109	.182	.211	.253	.293	.333	.372	.414	.455	.499	.544	.639	.741	.849	.963	1.09
1.0	.099	.166	.192	.231	.269	.306	.343	.381	.420	.461	.503	.592	.687	.788	.897	1.01
1.2	.083	.140	.163	.198	.231	.263	.296	.330	.364	.400	.437	.516	.601	.691	.788	.892
1.4	.071	.121	.142	.172	.202	.231	.260	.290	.321	.353	.387	.457	.533	.615	.703	.796
1.6	.062	.107	.125	.153	.179	.205	.232	.259	.287	.316	.346	.410	.480	.554	.634	.719
1.8	.055	.096	.112	.137	.161	.185	.209	.234	.259	.286	.314	.372	.436	.504	.578	.656
2.0	.050	.086	.102	.124	.146	.168	.190	.213	.237	.261	.287	.341	.399	.462	.531	.603
2.2	.045	.079	.093	.114	.134	.154	.175	.196	.218	.240	.264	.314	.368	.427	.490	.558
2.4	.042	.072	.085	.105	.124	.142	.162	.181	.201	.221	.244	.291	.342	.397	.456	.519
2.6	.038	.067	.079	.097	.115	.132	.150	.168	.187	.207	.228	.271	.319	.370	.426	.485
2.8	.036	.062	.074	.091	.107	.124	.140	.157	.175	.194	.213	.254	.299	.347	.399	.456
3.0	.033	.058	.069	.085	.100	.116	.132	.148	.164	.182	.200	.239	.281	.327	.376	.429
x	0	.008	.029	.056	.089	.125	.164	.204	.246	.289	.333	.424	.516	.601	.704	.800

ECCENTRIC LOADS ON WELD GROUPS

COEFFICIENTS



P = Permissible eccentric load in Kips.
l = Length of weld parallel to load "P" in inches.
D = Number of sixteenths of an inch in fillet weld size.
C = Coefficients tabulated below.
xl = Distance from vertical weld to center of gravity of weld group.

$$P = CDl$$

Required Minimum $C = \frac{P}{Dl}$

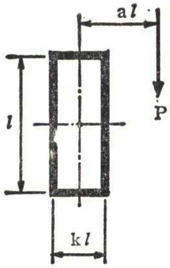
" " $D = \frac{P}{Cl}$

" " $l = \frac{P}{CD}$

a	k: 0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0
0.2	.384	.522	.655	.765	.868	.965	1.06	1.15	1.25	1.34	1.43	1.61	1.80	1.99	2.19	2.38
0.3	.291	.428	.544	.650	.748	.842	.930	1.02	1.10	1.19	1.27	1.44	1.61	1.79	1.97	2.15
0.4	.231	.357	.455	.554	.647	.735	.820	.902	.982	1.06	1.14	1.30	1.46	1.62	1.79	1.96
0.5	.190	.303	.387	.478	.564	.647	.727	.804	.881	.955	1.03	1.18	1.33	1.48	1.64	1.80
0.6	.161	.263	.335	.418	.498	.575	.650	.724	.795	.866	.936	1.08	1.22	1.36	1.51	1.66
0.7	.139	.231	.294	.369	.443	.516	.587	.655	.723	.790	.856	.988	1.12	1.26	1.40	1.54
0.8	.122	.206	.262	.331	.399	.467	.533	.598	.662	.726	.787	.913	1.04	1.17	1.30	1.44
0.9	.109	.186	.236	.299	.362	.425	.487	.549	.610	.670	.729	.847	.968	1.09	1.22	1.35
1.0	.099	.169	.214	.272	.331	.390	.449	.507	.564	.622	.678	.791	.905	1.02	1.14	1.26
1.2	.083	.143	.181	.231	.283	.335	.387	.439	.491	.542	.594	.697	.801	.906	1.02	1.13
1.4	.071	.124	.156	.200	.246	.293	.340	.387	.434	.481	.528	.622	.717	.815	.915	1.02
1.6	.062	.109	.137	.177	.217	.257	.300	.345	.388	.432	.474	.561	.649	.739	.832	.926
1.8	.055	.097	.122	.156	.191	.227	.263	.302	.344	.387	.431	.511	.593	.676	.762	.850
2.0	.050	.088	.111	.140	.171	.202	.235	.269	.305	.343	.380	.469	.545	.623	.703	.785
2.2	.045	.080	.100	.127	.154	.182	.211	.242	.274	.308	.344	.423	.505	.578	.653	.730
2.4	.042	.074	.091	.116	.141	.166	.192	.220	.249	.276	.312	.382	.462	.539	.609	.682
2.6	.038	.068	.084	.107	.129	.152	.176	.201	.228	.255	.285	.349	.421	.501	.571	.640
2.8	.036	.063	.077	.099	.120	.141	.163	.186	.210	.235	.262	.321	.382	.460	.537	.602
3.0	.033	.059	.073	.092	.113	.131	.151	.173	.195	.218	.243	.297	.358	.425	.500	.569
x	0	.008	.029	.056	.089	.125	.164	.204	.246	.289	.333	.424	.516	.601	.704	.800

ECCENTRIC LOADS ON WELD GROUPS

COEFFICIENTS



P = Permissible eccentric load in Kips.

l = Length of longer welds in inches.

D = Number of sixteenths of an inch in fillet weld size.

C = Coefficients tabulated below.

Note: When load "P" is perpendicular to longer side "l" use table on facing page.

$$P = CDl$$

Required Minimum $C = \frac{P}{Dl}$

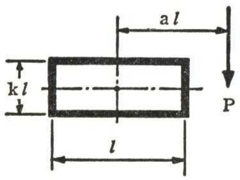
" " $D = \frac{P}{Cl}$

" " $l = \frac{P}{CD}$

a	k										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.2	.768	.892	1.01	1.11	1.21	1.31	1.41	1.50	1.60	1.70	1.80
0.3	.582	.703	.814	.920	1.02	1.12	1.21	1.30	1.40	1.49	1.58
0.4	.462	.570	.675	.775	.871	.963	1.05	1.14	1.23	1.32	1.41
0.5	.380	.475	.571	.665	.756	.844	.929	1.01	1.10	1.18	1.26
0.6	.322	.407	.494	.580	.665	.747	.828	.908	.985	1.06	1.14
0.7	.278	.355	.434	.514	.592	.670	.745	.821	.894	.968	1.04
0.8	.244	.314	.386	.460	.533	.606	.677	.748	.819	.888	.958
0.9	.218	.281	.348	.416	.485	.553	.620	.687	.754	.820	.885
1.0	.198	.255	.316	.380	.444	.508	.571	.635	.698	.760	.823
1.2	.166	.214	.267	.323	.380	.437	.493	.550	.607	.664	.721
1.4	.142	.185	.231	.281	.331	.382	.434	.485	.537	.589	.641
1.6	.124	.162	.204	.248	.294	.340	.387	.434	.481	.529	.577
1.8	.110	.145	.182	.222	.264	.306	.348	.392	.436	.479	.523
2.0	.100	.131	.165	.201	.239	.278	.318	.358	.398	.439	.480
2.2	.090	.119	.150	.184	.219	.255	.292	.329	.367	.404	.443
2.4	.084	.109	.138	.169	.202	.235	.269	.304	.339	.375	.411
2.6	.076	.101	.128	.156	.187	.218	.250	.283	.316	.349	.383
2.8	.072	.094	.119	.146	.174	.204	.234	.264	.296	.327	.359
3.0	.066	.088	.111	.136	.163	.191	.219	.248	.278	.308	.338

ECCENTRIC LOADS ON WELD GROUPS

COEFFICIENTS



P = Permissible eccentric load in Kips.
l = Length of longer welds in inches.
D = Number of sixteenths of an inch in fillet weld size.
C = Coefficients tabulated below.
Note: When load "P" is parallel to longer side "l" use table on facing page.

$$P = CDl$$

$$\text{Required Minimum } C = \frac{P}{Dl}$$

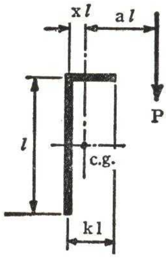
$$\text{" \quad " } D = \frac{P}{Cl}$$

$$\text{" \quad " } l = \frac{P}{CD}$$

a	k										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.2	.545	.662	.782	.905	1.03	1.16	1.28	1.41	1.54	1.67	1.80
0.3	.429	.530	.636	.746	.860	.976	1.10	1.22	1.34	1.46	1.58
0.4	.353	.442	.536	.635	.738	.844	.952	1.06	1.17	1.29	1.41
0.5	.300	.379	.463	.552	.645	.742	.842	.943	1.05	1.15	1.26
0.6	.261	.331	.407	.488	.573	.662	.753	.846	.943	1.04	1.14
0.7	.231	.294	.364	.438	.516	.597	.681	.768	.857	.948	1.04
0.8	.207	.265	.328	.397	.469	.544	.622	.703	.785	.871	.958
0.9	.187	.241	.299	.363	.429	.499	.574	.647	.725	.804	.885
1.0	.171	.221	.275	.334	.396	.462	.529	.599	.672	.746	.823
1.2	.146	.189	.237	.288	.343	.402	.460	.523	.587	.653	.721
1.4	.128	.166	.208	.253	.302	.354	.407	.463	.521	.580	.641
1.6	.113	.147	.185	.226	.270	.317	.365	.416	.468	.521	.577
1.8	.102	.132	.167	.204	.244	.287	.330	.377	.425	.474	.523
2.0	.092	.120	.152	.186	.223	.262	.303	.345	.389	.434	.480
2.2	.084	.110	.139	.171	.205	.241	.279	.318	.358	.400	.443
2.4	.078	.102	.129	.158	.190	.223	.258	.295	.332	.371	.411
2.6	.072	.095	.120	.147	.177	.208	.240	.275	.310	.346	.383
2.8	.067	.088	.112	.138	.165	.195	.227	.257	.290	.324	.359
3.0	.063	.083	.105	.129	.155	.183	.212	.242	.273	.305	.338

ECCENTRIC LOADS ON WELD GROUPS

COEFFICIENTS



P = Permissible eccentric load in Kips.

l = Length of weld parallel to load "P" in inches.

D = Number of sixteenths of an inch in fillet weld size.

C = Coefficients tabulated below.

xl = Distance from vertical weld to center of gravity of weld group.

$$P = CDl$$

$$\text{Required Minimum } C = \frac{P}{Dl}$$

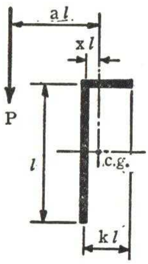
$$\text{“} \quad \text{“} \quad D = \frac{P}{Cl}$$

$$\text{“} \quad \text{“} \quad l = \frac{P}{CD}$$

a	k															
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0
0.2	.384	.434	.462	.484	.505	.527	.552	.582	.615	.651	.691	.778	.875	.977	1.09	1.20
0.3	.291	.337	.375	.394	.412	.431	.451	.476	.503	.534	.569	.645	.731	.823	.920	1.02
0.4	.231	.268	.301	.331	.347	.363	.381	.402	.426	.453	.483	.550	.627	.711	.800	.894
0.5	.190	.221	.248	.276	.299	.313	.329	.347	.368	.392	.419	.480	.549	.625	.707	.794
0.6	.161	.188	.211	.234	.263	.275	.290	.306	.325	.346	.370	.425	.489	.558	.634	.713
0.7	.139	.162	.182	.203	.225	.246	.258	.273	.290	.310	.332	.382	.440	.504	.574	.648
0.8	.122	.143	.161	.178	.198	.221	.233	.247	.262	.280	.300	.346	.400	.459	.525	.593
0.9	.109	.128	.143	.159	.176	.197	.212	.225	.239	.256	.274	.317	.367	.422	.483	.548
1.0	.099	.115	.129	.144	.159	.178	.195	.207	.220	.235	.252	.292	.338	.390	.447	.508
1.2	.083	.097	.108	.120	.133	.148	.167	.178	.189	.203	.218	.253	.293	.340	.390	.444
1.4	.071	.083	.093	.103	.114	.127	.143	.156	.166	.178	.191	.224	.259	.300	.346	.395
1.6	.062	.073	.081	.090	.100	.111	.125	.139	.148	.159	.171	.199	.232	.269	.310	.355
1.8	.055	.065	.073	.080	.089	.099	.111	.125	.134	.143	.154	.180	.210	.244	.282	.323
2.0	.050	.058	.065	.072	.080	.089	.100	.112	.122	.130	.140	.164	.191	.223	.258	.296
2.2	.045	.053	.059	.066	.073	.081	.091	.102	.112	.120	.129	.151	.176	.205	.238	.273
2.4	.042	.049	.055	.060	.066	.074	.083	.093	.103	.111	.119	.139	.163	.190	.220	.253
2.6	.038	.044	.050	.056	.062	.068	.077	.086	.096	.103	.111	.130	.152	.177	.205	.236
2.8	.036	.041	.047	.052	.057	.063	.071	.080	.090	.096	.105	.121	.142	.166	.192	.222
3.0	.033	.038	.044	.050	.054	.060	.066	.075	.084	.090	.097	.114	.133	.156	.181	.209
x	0	.005	.017	.035	.057	.083	.113	.144	.178	.213	.250	.327	.408	.492	.579	.667

ECCENTRIC LOADS ON WELD GROUPS

COEFFICIENTS



P = Permissible eccentric load in Kips.

l = Length of weld parallel to load "P" in inches.

D = Number of sixteenths of an inch in fillet weld size.

C = Coefficients tabulated below.

xl = Distance from vertical weld to center of gravity of weld group.

$$P = CDl$$

Required Minimum $C = \frac{P}{Dl}$

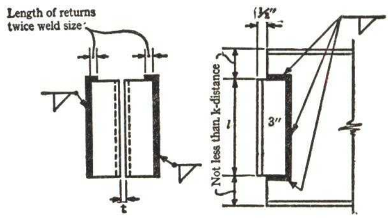
" " $D = \frac{P}{Cl}$

" " $l = \frac{P}{CD}$

a	k: 0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0
0.2	.384	.436	.478	.516	.554	.595	.638	.684	.733	.784	.837	.945	1.06	1.17	1.28	1.39
0.3	.291	.335	.369	.400	.432	.467	.505	.547	.593	.641	.691	.796	.904	1.01	1.12	1.24
0.4	.231	.267	.295	.321	.348	.379	.412	.450	.490	.534	.581	.680	.783	.889	.996	1.10
0.5	.190	.220	.244	.266	.290	.316	.346	.379	.415	.456	.498	.590	.688	.788	.890	.993
0.6	.161	.187	.207	.227	.247	.270	.296	.326	.359	.395	.435	.520	.611	.706	.803	.902
0.7	.139	.162	.178	.197	.215	.236	.259	.286	.316	.349	.385	.463	.548	.638	.730	.824
0.8	.122	.143	.159	.174	.190	.209	.230	.254	.281	.312	.344	.417	.497	.581	.669	.758
0.9	.109	.127	.142	.156	.170	.187	.207	.229	.253	.281	.312	.379	.454	.533	.616	.702
1.0	.099	.115	.128	.141	.154	.170	.187	.208	.231	.256	.284	.347	.417	.493	.571	.652
1.2	.083	.096	.107	.118	.129	.143	.158	.175	.195	.217	.242	.297	.359	.427	.498	.572
1.4	.071	.083	.092	.102	.112	.123	.136	.151	.169	.189	.210	.259	.315	.376	.440	.508
1.6	.062	.073	.081	.089	.098	.108	.120	.133	.149	.171	.186	.233	.280	.336	.395	.457
1.8	.055	.065	.072	.079	.087	.096	.107	.119	.133	.149	.166	.207	.253	.303	.358	.421
2.0	.050	.058	.065	.072	.079	.087	.096	.108	.120	.135	.151	.187	.230	.276	.327	.380
2.2	.045	.053	.059	.065	.072	.079	.088	.098	.110	.123	.138	.171	.210	.254	.301	.351
2.4	.042	.049	.054	.060	.066	.073	.081	.090	.100	.113	.127	.158	.194	.235	.279	.325
2.6	.038	.045	.050	.055	.061	.067	.075	.083	.093	.105	.117	.147	.180	.218	.259	.303
2.8	.036	.042	.047	.051	.056	.062	.069	.077	.087	.097	.109	.137	.168	.204	.243	.284
3.0	.033	.039	.043	.048	.053	.058	.065	.072	.081	.092	.102	.128	.158	.191	.228	.267
x	0	.005	.017	.035	.057	.083	.113	.144	.178	.213	.250	.327	.408	.492	.579	.667

WELDED BEAM WEB CONNECTIONS

ALLOWABLE LOADS-KIPS



l in.	Size of angles	Weld Size Shop	Weld Size Field	R-Value Shop welds	R-Value Field welds	Min. beam web thick-ness	l in.	Size of angles	Weld Size Shop	Weld Size Field	R-Value Shop welds	R-Value Field welds	Min. beam web thick-ness
						Web thickness of all 27, 30, 33 and 36WF adequate to develop tabulated R-values	14	3 x 3 x 7/16	5/16	3/8	76	80	.47
							14	*3 x 3 x 3/8*	5/16	5/16	*76*	*66*	*.41*
							13	3 x 3 x 7/16	5/16	3/8	69	72	.47
32	4 x 3 x 7/16	5/16	3/8	192	210		*13*	*3 x 3 x 3/8*	5/16	5/16	*69*	*60*	*.40*
31	4 x 3 x 7/16	5/16	3/8	186	202		12	3 x 3 x 7/16	5/16	3/8	64	64	.47
30	4 x 3 x 7/16	5/16	3/8	180	195		*12*	*3 x 3 x 3/8*	5/16	5/16	*64*	*54*	*.40*
29	4 x 3 x 7/16	5/16	3/8	173	187		11	3 x 3 x 7/16	5/16	3/8	57	57	.47
28	4 x 3 x 7/16	5/16	3/8	167	179		*11*	*3 x 3 x 3/8*	1/4	5/16	*46*	*47*	*.38*
27	4 x 3 x 7/16	5/16	3/8	160	172		10	3 x 3 x 7/16	5/16	3/8	51	49	.45
26	4 x 3 x 7/16	5/16	3/8	154	164		*10*	*3 x 3 x 3/8*	1/4	5/16	*41*	*41*	*.38*
25	4 x 3 x 7/16	5/16	3/8	147	156		9	3 x 3 x 7/16	5/16	3/8	45	41	.43
24	4 x 3 x 7/16	5/16	3/8	141	148		*9*	*3 x 3 x 3/8*	1/4	5/16	*36*	*35*	*.38*
23	4 x 3 x 7/16	5/16	3/8	139	140		8	3 x 3 x 7/16	5/16	3/8	39	34	.41
22	4 x 3 x 7/16	5/16	3/8	128	133		*8*	*3 x 3 x 3/8*	1/4	5/16	*31*	*29*	*.35*
21	4 x 3 x 7/16	5/16	3/8	121	125		7	3 x 3 x 7/16	5/16	3/8	33	27	.38
20	4 x 3 x 7/16	5/16	3/8	115	117		*7*	*3 x 3 x 3/8*	1/4	5/16	*27*	*23*	*.32*
19	4 x 3 x 7/16	5/16	3/8	108	109	.47	6	3 x 3 x 7/16	1/4	3/8	22	21	.35
18	4 x 3 x 7/16	5/16	3/8	102	101	.47	*6*	*3 x 3 x 3/8*	1/4	5/16	*22*	*17.5*	*.29*
18	*3 x 3 x 3/8*	5/16	5/16	*102*	*93*	*.43*	5	3 x 3 x 7/16	1/4	3/8	18	15	.31
17	3 x 3 x 3/8	5/16	5/16	95	86	.42	*5*	*3 x 3 x 3/8*	3/16	5/16	*13.5*	*12.5*	*.26*
16	3 x 3 x 3/8	5/16	5/16	89	80	.42	4	3 x 3 x 7/16	3/16	3/8	10.5	10	.27
15	3 x 3 x 3/8	5/16	5/16	82	73	.42	*4*	*3 x 3 x 3/8*	3/16	5/16	*10.5*	*8.5*	*.23*

When the connection is both shop and field welded use lesser of the two given R-values.

When connection is shop welded and beam web thickness is less than figure shown in column headed "Min. beam web thick." multiply R-value of shop weld by given web thickness and divide by tabulated minimum thickness. Make same adjustment for field weld if its R-value is less than that of shop weld. For best economy in such cases use connections shown in italics.

Example:

Required to frame a 14WF30 beam having a reaction of 20 kips and web thickness of .27 in.

Try 2∟s 3 x 3 x 3/8 x 0′-8, having R-Value ot 29 kips when web thickness is .35 in.

For given beam allowable $R = 29 \times \frac{.27}{.35} = 22.3$ kips. Connection is adequate.

UNSTIFFENED WELDED SEAT ANGLES

ALLOWABLE LOADS IN KIPS

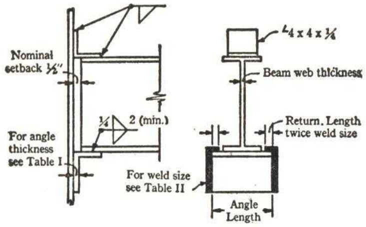


TABLE I Seat Angle Length and Thickness
Outstanding Leg of Angle 3½″ or 4″

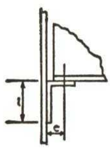
Thickness of Beam Web	Length = 6″						Length = 8″					
	Thickness of Seat Angle						Thickness of Seat Angle					
	3/8″	1/2″	5/8″	3/4″	7/8″	1″	3/8″	1/2″	5/8″	3/4″	7/8″	1″
3/16	6	9	11	14	16	16	7	10	13	15	16	16
1/4	8	11	14	17	20	23	9	12	16	19	22	23
5/16	10	15	18	21	25	28	11	16	20	24	27	31
3/8	11	17	22	26	30	34	12	19	24	28	32	36
7/16	12	18	25	30	34	39	13	21	27	32	37	42
1/2	12	20	28	34	39	44	14	22	31	37	42	47
9/16	14	21	30	39	44	50	15	24	34	42	48	50

Values above the zig-zag line apply only for 4″ outstanding legs.

Table I same as for riveted seats; See Manual page 263.

Nominal beam setback ½ in.; allowable loads based on assumption tnat beam length may under-run, making this figure ¾ in.

Table II Weld Length and Size



Weld Size Required*	Load on Seat and Size of Seat Angle					
	4 x 3½	5 x 3½	6 x 4	7 x 4	8 x 4	9 x 4
1/4	7	11	14	18	23	27
5/16	9	13	17	23	28	34
3/8	11	16	21	27	34	41
7/16	13	19	24	32	40	48
1/2	14	22	28	36	46	50
5/8	----	----	35	46	50	

*Unless controlled by A.I.S.C. Spec. Sect. 24(c).
Entries above zig-zag line are usually least costly.

Allowable loads on welds computed as

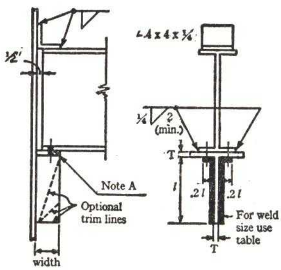
$$R = \frac{1.2\,lD}{\sqrt{1+\left(\frac{4.5e}{l}\right)^2}}$$

where l = length of vertical welds in inches
D = number of sixteenths of an inch in weld size
e = ¾ in. plus one-half of remaining width of outstanding leg

No reduction ot the tabulated loads required when unstiffened seats are lined up on opposite sides of supporting web.

STIFFENED WELDED BEAM SEATS

ALLOWABLE LOADS IN KIPS



Note A

If seat and stiffener are separate plates, fit stiffener to bear against seat. Connecting welds should have strength equivalent to horizontal welds on column under seat plate.

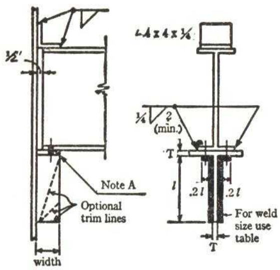
Minimum plate thickness T, at least 1.5 times required weld size, but not less than beam web thickness.

For stiffened seats in line on opposite sides of column web, use weld size no greater than ⅔ column web thickness.

l inches	WIDTH OF SEAT											
	4 in.				5 in.				6 in.			
	Size of Welds				Size of Welds				Size of welds			
	¼ in.	5/16 in.	⅜ in.	7/16 in.	5/16 in.	⅜ in.	7/16 in.	½ in.	5/16 in.	⅜ in.	7/16 in.	½ in.
6	15	18	22	26	15	18	21	24	----	----	----	21
7	19	24	29	34	21	25	29	33	----	21	25	28
8	24	31	37	43	26	31	36	41	22	27	31	35
9	30	37	45	52	32	38	44	51	28	33	39	44
10	35	44	53	62	38	46	53	61	33	40	47	53
11	41	51	62	72	45	54	63	72	39	47	55	63
12	47	59	71	83	52	62	73	83	46	55	64	73
13	----	67	80	93	59	71	83	94	52	63	73	84
14	---	74	89	104	66	80	93	106	59	71	83	95
15	----	82	99	115	74	89	103	118	66	80	93	106
16	----	90	108	126	81	98	114	130	74	89	103	118
17	---	98	117	137	89	107	125	143	81	97	114	130
18	----	106	127	148	97	119	138	158	89	106	124	142
19	----	113	136	----	105	126	146	167	96	115	135	154
20	----	121	145	----	112	135	157	----	104	125	145	166
21	----	128	----	----	120	144	168	----	112	134	156	178
22	----	137	----	----	128	154	----	----	119	143	167	191
23	----	145	----	----	136	163	----	----	127	153	178	----
24	----	----	----	----	144	173	----	----	135	162	189	----
25	----	----	----	----	152	----	----	----	143	171	----	----
26	----	----	----	----	159	----	----	----	151	181	----	----
27	----	----	----	----	161	----	----	----	158	190	----	----

STIFFENED WELDED BEAM SEATS

ALLOWABLE LOADS IN KIPS



Note A

If seat and stiffener are separate plates, fit stiffener to bear against seat. Connecting welds should have strength equivalent to horizontal welds on column under seat plate.

Minimum plate thickness T, at least 1.5 times required weld size, but not less than beam web thickness.

For stiffened seats in line on opposite sides of column web, use weld size no greater than ⅔ column web thickness.

l inches	WIDTH OF SEAT											
	7 in.				8 in.				9 in.			
	Size of Welds				Size of Welds				Size of Welds			
	5/16 in.	3/8 in.	7/16 in.	1/2 in.	5/16 in.	3/8 in.	1/2 in.	5/8 in.	5/16 in.	3/8 in.	1/2 in.	5/8 in.
11	35	42	49	56	----	----	----	63	----	----	----	----
12	41	49	57	65	----	----	59	73	----	----	----	----
13	47	56	66	75	----	----	68	84	----	----	----	77
14	53	64	75	85	----	58	77	97	----	----	----	88
15	60	72	84	96	55	65	87	109	----	----	80	100
16	67	80	94	107	61	73	98	122	----	----	90	112
17	74	89	104	118	68	81	108	135	----	75	100	124
18	81	97	114	130	75	89	119	149	----	82	110	137
19	88	106	124	142	82	98	130	163	75	90	121	151
20	96	115	134	153	89	106	142	177	82	99	131	164
21	103	124	145	165	96	115	153	192	89	107	143	178
22	111	133	155	178	103	124	165	206	96	115	154	192
23	119	142	166	190	111	133	177	221	103	124	165	207
24	126	152	177	202	118	142	189	236	111	133	177	221
25	134	161	188	214	126	151	201	----	118	142	189	236
26	142	170	199	----	133	160	213	----	125	151	201	251
27	150	180	209	----	141	169	226	----	133	160	212	266
28	157	189	220	----	149	179	238	----	141	169	225	----
29	165	198	----	----	157	188	----	----	148	178	237	----
30	173	208	----	----	164	197	----	----	156	187	249	----
31	181	217	----	----	172	207	----	----	164	196	262	----
32	189	----	----	----	180	216	----	----	171	206	----	----

AMERICAN INSTITUTE OF STEEL CONSTRUCTION INC.

AISC

FOUNDED 1921

STEEL JOIST INSTITUTE

STANDARD SPECIFICATIONS
AND
LOADING TABLE

OPEN WEB STEEL JOISTS
LONGSPAN SERIES

(MANUAL STEEL CONSTRUCTION SUPPLEMENT)

AMERICAN INSTITUTE OF STEEL CONSTRUCTION
101 PARK AVENUE
NEW YORK 17, N. Y.

Pending the publication of a new edition of the AISC Manual, this means is being taken to place in the hands of all users of the Fifth Edition, the Steel Joist Institute's recently adopted Standard Specifications and Loading Table for Open Web Steel Joists, LONGSPAN SERIES.

Standard Specifications

FOR OPEN WEB STEEL JOISTS — LONGSPAN SERIES

Adopted by the Steel Joist Institute, April 28, 1953. Effective April 28, 1953.

Adopted by the American Institute of Steel Construction, Inc. June 10, 1954.

Section 1. Scope

(a) These specifications cover the design and use of "Longspan" Series Open Web Joists in any structure to be erected under the provisions of these specifications.

(b) "Longspan Steel Joist construction" as governed by these specifications shall be that type of construction where decks and top slabs are supported directly by separate steel members herein referred to as "Longspan" Steel Joists. The span and spacing of "Longspan" Steel Joists shall be as defined in Section 6 of these specifications.

Section 2. Definition of "Longspan" Steel Joists

(a) The term "Longspan" Steel Joist as used herein refers to relatively lightweight steel trusses having substantially parallel chords and designed for the direct support of floors, roof slabs and decks, between walls, beams and main structural trusses at spans and spacings specified in Section 6.

(b) This specification shall not be construed to cover steel joists or steel joist construction as defined by the Standard Specifications for "Shortspan" Open Web Steel Joist Construction of the Steel Joist Institute.

Section 3. Materials

(a) The steel used shall conform to the American Society for Testing Materials Standard Specifications for Steel for Bridges and Buildings, Designation A7 of latest adoption.

(b) All "Longspan" Steel Joists shall receive one coat of rust-inhibitive paint before leaving the manufacturer's shop.

(c) Top and bottom chords of "Longspan" Steel Joists shall be composed of angles or other shapes. Web members shall consist of angles, bars, or other shapes.

Section 4. Connections

(a) All joints of "Longspan" Steel Joists shall be made by welding, bolting, riveting or other approved methods. Connections at ends of members shall be proportioned to develop the actual design stress but not less than 50% of the allowable design strength of the members.

Section 5. Design and Stresses

(a) Except as otherwise specified herein, "Longspan" Steel Joists shall be designed as structural trusses in accordance with the American Institute of Steel Construction "Specification for Design, Fabrication and Erection of Structural Steel for Buildings".

(b) The top chords shall be designed as continuous members subject to direct and bending stresses. The allowable bending stress at mid-panels and at panel points shall be 20,000 PSI and 24,000 PSI respectively.

(c) The unsupported length of top chord for the purpose of computing the permissible axial compressive stress at mid-panel and at panel point shall be considered equal to the panel length and half the panel length respectively.

(d) The method of attachment of floors or roof decks and slabs shall be adequate to support the top chords laterally.

Section 6. Span and Spacing

(a) The clear span of "Longspan" Steel Joists shall not exceed twenty-four times the depth for roofs or twenty times the depth for floors.

Standard Specifications (Continued)

FOR OPEN WEB STEEL JOISTS — LONGSPAN SERIES

(b) Where "Longspan" Steel Joists rest on masonry walls, it is recommended that the clear span be limited to 80'-0" and that the masonry walls be adequately designed with respect to height, thickness and spacing of pilasters.

(c) The spacing of the "Longspan" Steel Joists shall not exceed the safe span of the floor slab or roof deck.

Section 7. Approximate Camber

(a) All "Longspan" Steel Joists shall have approximate cambers in accordance with the following:

Top Chord Length	Camber
30'-0"	3/8"
40'-0"	5/8"
50'-0"	1 1/8"
60'-0"	1 1/2"
70'-0"	2 1/8"
80'-0"	2 3/4"
90'-0"	3 1/2"
96'-0"	4"

Section 8. Bearing and Anchorage

(a) Where "Longspan" Steel Joists are supported by masonry or concrete walls, the joists shall be anchored by a 3/4" round bar anchor not less than 12" long or other equivalent method. Where "Longspan" Steel Joists rest on steel beams or steel trusses they shall be connected with not less than two 3/4" bolts or welds of equal strength.

(b) The ends of "Longspan" Joists shall bear not less than 6" on masonry or concrete and not less than 4" on steel The bearing areas shall be such that the average bearing pressure does not exceed 250 pounds per square inch on brick or stone masonry and 600 pounds per square inch on poured concrete.

Section 9. Bridging

Bridging shall consist of a cross-bracing with l/r ratio of not more than 200 where "l" is the distance in inches between connections and "r" is the least radius of gyration of the bracing member. Where cross-bracing members are connected at their point of intersection, the "l" distance shall be taken as the distance in inches between connections at the point of intersection of the bracing members and the connection to the chord of the "Longspan" Joist.

The maximum spacing of lines of bridging for the different joist types shall not exceed the values tabulated below:

Joist Type	Maximum Spacing of Lines of Bridging
No. 2 to No. 8 incl.	10'-0"
No. 9 to No. 16 incl.	12'-0"
No. 17 to No. 19 incl.	16'-0"

Section 10. Inspection

(a) All "Longspan" Joists shall be thoroughly inspected before shipment to make certain that materials and workmanship conform to the requirements of these specifications.

Section 11. Erection

(a) "Longspan" Steel Joists shall be unloaded from shipping facilities, erected and hoisted into place by hooking to the top chord of joists at approximately the third points. Hoisting facilities shall not be released during erection procedure until the line of bridging nearest mid-span is installed, and in the case of bottom chord bearing "Longspan" Joists, the ends of the top chords shall be restrained laterally. Care shall be exercised at all times to avoid damage through careless handling. As soon as "Longspan" Joists are erected they shall be permanently fastened in place and all bridging completely installed before the application of loads.

Standard Loading Table

FOR LONGSPAN STEEL JOISTS

Adopted by the Steel Joist Institute, April 28, 1953. Effective April 28, 1953.

Adopted by the American Institute of Steel Construction, Inc. June 10, 1954.

The following table gives the TOTAL safe uniformly distributed load-carrying capacities of "Longspan" Joists in pounds per linear foot of span.

This load table applies to "Longspan" Joists with either parallel chords or standard pitched top chords. The carrying capacities of "Longspans" with top chords pitched is determined by the nominal depth of the "Longspan" Joists at the center of the span.

Standard pitch is 1/8" per foot. If pitch exceeds this standard, the load table does not apply.

Figures printed to the right of the heavy vertical lines to be used for roof construction only.

Loads below heavy broken horizontal lines are governed by maximum end reaction.

Joist Designation	Approx. Wt. in Lbs. per Linear Ft.	Depth in Inches	Maximum End Reaction	Clear Opening or Net Span in Feet											
				25	26	27	28	29	30	31	32	33	34	35	36
18L02	13	18	3,632	283	267	251	237	224	211	200	190	180	171	163	155
18L03	14	18	4,094	319	300	283	267	253	239	227	215	204	194	185	176
18L04	16	18	4,941	385	361	339	319	301	284	268	254	241	229	217	207
18L05	17	18	5,364	418	394	372	351	331	313	298	282	268	254	242	231
18L06	19	18	6,417	500	469	440	414	391	369	349	330	313	297	282	268
18L07	21	18	6,880	536	516	486	458	432	408	386	365	346	329	313	296
18L08	23	18	7,482	583	561	541	522	491	463	437	414	392	371	352	335
18L09	25	18	7,697	600	577	556	537	519	502	474	449	425	403	383	364
18L10	27	18	8,265	644	620	597	577	557	539	522	493	466	442	419	398
18L11	29	18	8,753	682	656	633	611	590	571	553	536	520	493	469	445
18L12	31	18	9,166	714	687	663	639	618	598	579	561	544	529	514	488

Joist Designation	Approx. Wt. in Lbs. per Linear Ft.	Depth in Inches	Maximum End Reaction	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
20L03	14	20	4,235	330	312	296	280	266	252	240	228	217	207	197	188	180	172	164	157
20L04	16	20	5,185	404	381	360	340	320	304	288	273	259	247	235	224	213	204	194	186
20L05	17	20	5,557	433	409	387	367	348	331	314	299	285	271	259	247	236	226	216	207
20L06	19	20	6,763	527	496	467	441	417	395	374	355	337	320	305	290	277	264	252	241
20L07	21	20	7,110	554	533	514	486	459	435	412	391	372	354	337	321	306	292	279	267
20L08	23	20	7,832	610	587	566	546	528	499	472	447	425	403	383	365	348	332	317	303
20L09	25	20	8,107	632	608	586	566	547	529	512	485	460	437	416	396	377	360	344	329
20L10	27	20	8,568	668	643	619	598	578	559	541	525	509	483	459	436	415	396	378	361
20L11	29	20	9,095	709	682	657	634	613	593	574	557	540	525	510	485	462	441	421	403
20L12	31	20	9,605	748	720	694	670	647	626	607	588	571	554	539	524	510	486	463	442
20L13	36	20	10,533	821	790	761	735	710	687	665	645	626	608	591	575	559	545	531	518

Joist Designation	Approx. Wt. in Lbs. per Linear Ft.	Depth in Inches	Maximum End Reaction	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
24L04	16	24	4,798	285	272	260	249	238	228	219	210	201	193	186	179	172	166	160	154
24L05	17	24	5,117	304	292	279	268	257	247	237	228	219	211	203	196	189	182	175	169
24L06	19	24	6,245	371	354	339	324	310	297	284	273	262	251	242	232	224	215	207	200
24L07	21	24	6,868	408	390	373	357	342	328	314	301	289	278	267	257	248	238	230	222
24L08	23	24	7,996	475	453	432	412	394	377	361	346	332	318	306	294	283	272	262	252
24L09	25	24	8,652	514	490	468	447	427	409	391	375	360	345	331	319	306	295	284	274
24L10	27	24	9,345	555	539	524	500	477	456	436	417	400	383	368	353	339	326	314	302
24L11	29	24	9,686	575	559	543	528	514	501	480	460	441	424	407	391	376	362	349	336
24L12	31	24	10,431	619	601	585	569	554	539	526	513	491	471	452	434	417	401	386	371
24L13	36	24	11,479	682	662	644	626	610	594	579	565	551	538	526	514	494	475	457	440
24L14	38	24	12,087	718	697	678	659	642	625	609	594	580	567	554	541	529	518	496	476

Joist Designation	Approx. Wt. in Lbs. per Linear Ft.	Depth in Inches	Maximum End Reaction	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
28L06	19	28	5,875	282	272	262	253	244	235	227	220	212	205	199	192	186	180	175	170
28L07	21	28	6,479	311	300	289	279	269	260	251	243	235	227	220	213	206	200	194	188
28L08	23	28	7,542	362	348	335	323	312	300	290	280	270	261	252	244	236	229	221	215
28L09	25	28	8,167	392	377	363	350	337	325	314	303	293	283	274	265	256	248	240	233
28L10	27	28	9,208	442	425	408	393	378	365	351	339	327	316	305	295	285	276	267	259
28L11	29	28	10,000	480	463	445	429	414	399	385	372	359	347	336	325	314	304	295	286
28L12	31	28	10,960	526	514	502	483	465	448	432	417	402	388	375	363	351	339	328	318
28L13	36	28	12,202	586	572	559	546	534	523	512	494	477	460	445	430	415	402	389	377
28L14	38	28	12,793	614	600	586	573	561	549	537	526	515	505	488	471	455	440	426	412
28L15	43	28	13,443	645	630	616	602	589	576	564	552	541	531	520	510	501	482	465	449

Standard Loading Table (Continued)

Joist Designation	Approx. Wt. in Lbs. per Linear Ft.	Depth in Inches	Maximum End Reaction	Clear Opening or Net Span in Feet															
				49	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**
32L07	21	32	6,159	248	240	233	226	220	213	207	201	196	190	185	180	175	171	166	162
32L08	23	32	7,177	289	280	271	263	256	248	241	234	227	220	214	208	202	197	191	186
32L09	25	32	7,798	314	304	295	285	277	269	260	253	246	239	232	225	219	213	207	202
32L10	27	32	8,791	354	343	332	321	311	302	292	283	275	267	259	252	245	238	231	225
32L11	29	32	9,586	386	374	362	351	340	330	321	311	302	294	285	277	270	262	255	249
32L12	31	32	10,827	436	422	409	396	383	371	360	349	339	329	319	310	301	293	285	277
32L13	36	32	12,667	510	500	485	469	453	440	427	414	401	390	378	367	357	347	338	328
32L14	38	32	13,470	543	532	522	512	502	486	471	457	443	429	417	404	393	382	371	360
32L15	43	32	14,445	582	570	559	549	538	528	519	510	501	484	468	452	438	424	411	398
32L16	48	32	15,729	633	621	609	597	586	575	565	555	546	536	527	519	510	502	487	472
				57	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**
36L08	23	36	6,920	240	234	227	221	216	210	205	199	194	189	185	180	176	172	167	164
36L09	25	36	7,497	260	253	246	240	233	227	221	216	210	205	200	195	191	186	182	177
36L10	27	36	8,506	295	287	279	271	264	257	250	243	237	231	225	219	214	209	204	199
36L11	29	36	9,198	319	310	302	294	286	279	272	265	258	252	246	240	234	228	223	218
36L12	31	36	10,467	363	352	343	333	324	316	307	299	291	284	277	270	263	257	250	244
36L13	36	36	12,398	430	418	406	395	384	374	364	355	346	337	328	320	312	304	297	290
36L14	38	36	13,782	478	464	451	438	426	414	403	392	382	372	362	353	344	336	327	319
36L15	43	36	15,275	530	521	512	497	484	471	458	446	434	423	412	400	389	378	368	357
36L16	48	36	16,482	572	562	552	543	535	526	518	510	502	489	476	464	453	442	431	420
36L17	54	36	17,765	616	606	595	586	576	567	558	549	541	533	525	517	510	497	485	473
				65	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
40L09	25	40	7,223	220	215	210	205	200	196	191	187	183	179	175	171	168	164	161	157
40L10	27	40	8,208	250	244	238	233	227	222	217	212	207	202	198	193	189	185	181	177
40L11	29	40	8,865	270	264	258	252	246	241	235	230	225	220	215	211	206	202	198	193
40L12	31	40	10,113	308	301	294	287	280	273	267	261	255	249	243	238	233	228	223	218
40L13	36	40	12,017	366	357	348	340	332	324	316	309	302	295	289	282	276	270	264	259
40L14	38	40	13,396	408	397	387	378	369	360	351	343	335	327	320	312	305	299	292	286
40L15	43	40	15,136	461	450	439	428	418	408	399	389	380	372	363	355	347	341	332	324
40L16	48	40	17,187	523	516	508	495	483	472	461	450	440	430	420	410	401	392	384	376
40L17	54	40	18,421	561	553	545	537	529	521	514	507	495	484	473	463	452	442	433	423
40L18	61	40	19,981	609	599	591	582	574	566	558	550	542	535	528	521	515	508	496	485
				73	**74**	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**
44L10	27	44	7,993	217	212	208	203	199	195	191	187	183	179	176	172	169	165	162	159
44L11	29	44	8,582	233	228	224	219	215	210	206	202	198	194	191	187	183	180	177	173
44L12	31	44	9,835	267	261	256	250	245	240	235	230	225	221	216	212	208	204	200	196
44L13	36	44	11,639	316	310	303	297	290	284	278	273	267	262	257	251	246	242	237	232
44L14	38	44	13,039	354	346	338	331	324	317	310	304	297	291	285	279	274	268	263	258
44L15	43	44	14,733	400	392	383	375	367	359	352	344	337	330	324	317	311	305	299	293
44L16	48	44	17,054	463	453	443	434	424	415	407	398	390	382	374	367	360	352	345	339
44L17	54	44	19,040	517	510	499	489	478	468	458	449	439	430	422	413	405	397	389	382
44L18	61	44	20,743	563	556	548	541	534	527	521	514	508	497	487	477	467	457	448	439
44L19	68	44	22,311	606	598	590	582	575	567	560	553	546	540	533	527	521	515	509	498
				81	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**
48L11	29	48	8,330	204	200	197	193	189	186	183	179	176	173	170	167	164	162	159	156
48L12	31	48	9,596	235	230	226	221	217	213	209	205	201	198	194	191	187	184	181	178
48L13	36	48	11,352	278	273	268	262	257	253	248	243	239	234	230	226	222	218	214	211
48L14	38	48	12,740	312	305	299	294	288	282	277	272	266	261	257	252	247	243	238	234
48L15	43	48	14,373	352	345	338	332	326	319	313	308	302	296	291	285	280	275	270	266
48L16	48	48	16,660	408	400	392	384	377	370	363	356	349	343	337	331	325	319	313	308
48L17	54	48	18,743	459	450	441	433	425	416	409	401	394	386	379	372	366	359	353	346
48L18	61	48	21,336	523	516	510	504	494	485	475	466	457	448	440	432	424	416	408	401
48L19	68	48	23,029	564	557	550	544	538	531	525	519	514	508	498	489	480	471	462	454

The weight of dead loads, including the weight of "Longspans", must in all cases be deducted to determine the live load-carrying capacities which must be reduced for concentrated loads. Approximate weights per linear foot of "Longspans" include accessories.

When holes are required in top or bottom chords the above carrying capacities must be reduced in proportion to reduction of chord areas.

The top chords are considered as being stayed laterally by floor slab or roof deck.